#341
1-15

PROCEEDINGS

OF THE

AMERICAN ACADEMY

OF

ARTS AND SCIENCES.

VOL. XXXV.

FROM MAY, 1899, TO MAY, 1900.

BOSTON, MASS.:
JOHN WILSON AND SON.
University Press.
1900.

CONTENTS.

Proceedings of the American Academy of Arts and Sciences.

Vol. XXXV. No. 1. — July, 1899.

CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF HARVARD COLLEGE.

THE DEVELOPMENT AND APPLICATION OF A GENERAL EQUATION FOR FREE ENERGY AND PHYSICO-CHEMICAL EQUILIBRIUM.

By Gilbert Newton Lewis.

Proceedings of the American Academy of Arts and Sciences.

VOL. XXXV. No. 1.—JULY, 1899.

CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF HARVARD COLLEGE.

THE DEVELOPMENT AND APPLICATION OF A GENERAL EQUATION FOR FREE ENERGY AND PHYSICO-CHEMICAL EQUILIBRIUM.

BY GILBERT NEWTON LEWIS.

THE DEVELOPMENT AND APPLICATION OF A GENERAL EQUATION FOR FREE ENERGY AND PHYSICO-CHEMICAL EQUILIBRIUM.

By Gilbert Newton Lewis.

Received June 5, 1899. Presented by T. W. Richards, June 14, 1899.

Introduction.

The advance of modern physical chemistry has been largely due to the application to physico-chemical problems of the first and second laws of thermodynamics and the gas law, — the latter both directly and by analogy. Upon this basis the whole theoretical treatment of chemical equilibrium rests at present. For this reason it may not be without interest to attempt to express the relations deduced from these laws in a single equation, the most convenient and the most general possible, which may serve to systematize a part of our present knowledge, and perhaps point out new laws. Such an attempt will be made in this paper.

I. General Equations of Free Energy and Equilibrium.

The simplest expression embodying the first and second laws of thermodynamics is,

$$A = T\frac{dA}{dT} + U, \tag{1}$$

where A is the diminution in free energy (Helmholtz) of a system in any isothermal process; U is the diminution in internal energy in the same process; T is the absolute temperature; $\frac{dA}{dT}$ represents the change in A as the temperature of the process varies, — the system changing in every case from the same initial to the same final volume.

A, the diminution of free energy, is a quantity which denotes the maximum amount of work obtainable in an isothermal process, and which is determined definitely by the initial and final states of a system. It may,

therefore, be expressed as the difference between two quantities, one representing what may be called the total free energy of the initial state; the other, the total free energy of the final state. Representing these quantities by $\mathfrak{A}_1$ and $\mathfrak{A}_2$, we have,

$$A = \mathfrak{A}_1 - \mathfrak{A}_2 .$$

Similarly, if we represent by $\mathfrak{U}_1$ the total internal energy of the system in the initial state, and by $\mathfrak{U}_2$ the same in the final state,

$$U = \mathfrak{U}_1 - \mathfrak{U}_2 ,$$

equation (1) may be written,

$$\mathfrak{A}_1 - \mathfrak{A}_2 = T\frac{d\,\mathfrak{A}_1}{d\,T} - T\frac{d\,\mathfrak{A}_2}{d\,T} + \mathfrak{U}_1 - \mathfrak{U}_2 ,$$

$\frac{d\,\mathfrak{A}_1}{d\,T}$ and $\frac{d\,\mathfrak{A}_2}{d\,T}$ being taken at constant volume.

This equation may be separated into two equations,

$$\mathfrak{A}_1 = T\frac{d\,\mathfrak{A}_1}{d\,T} + \mathfrak{U}_1 + M, \tag{2a}$$

and

$$\mathfrak{A}_2 = T\frac{d\,\mathfrak{A}_2}{d\,T} + \mathfrak{U}_2 + M, \tag{2b}$$

where M is an undeterminable quantity which can have only arbitrary physical significance, since we are in practice only concerned with changes of free energy at constant temperature, and in such changes M always disappears.

In two special cases, viz. the ideal gas and the dilute solution, the expression for the change in free energy has been found to assume a very simple form,

$$A = n\,R\,T \ln \frac{v_2}{v_1} ,$$

where n denotes the number of gram-molecules of the gas or solute; R, the gas constant; T, the absolute temperature; ln, a natural logarithm; v_1 and v_2 respectively, the initial and final molecular volumes. Although the above expression gives a complete statement for the change in free energy only in the two special cases mentioned, still we are led by many considerations to believe that it forms an important factor in many other, if not all, free energy changes. Evidence on this point is offered by the fact that the above term is present in the general equations of equilibrium which have found experimental verification in the most

diverse systems. Moreover, we are led to the above expression for free energy change by the kinetic theory, the extended application of which to much more complicated cases than that of a perfect gas has already produced important results.

The term $n R T \ln \frac{v_2}{v_1}$ may be written in the form

$$- n R T \ln v_1 + n R T \ln v_2 .$$

Then we may consider that the quantity $- n R T \ln v_1$ represents an essential part of the free energy of n gram-molecules of a simple substance in a given state, and similarly, $n R T \ln v_2$, a similar part of the free energy in another state, and we may write for the free energy of one gram-molecule of a simple substance the entirely arbitrary equation,

$$\mathfrak{A}_1 = - R T \ln v_1 + x_1 ,$$

where x_1 represents that part of the free energy not contained in the term $- R T \ln v_1$; differentiating this equation,

$$\frac{d \mathfrak{A}_1}{d T} = - R \ln v_\cdot + y_1 , \qquad (3)$$

where $y_1 = \frac{d x_1}{d T}$.

Now substituting in equation $(2 a)$,

$$\mathfrak{A}_1 = - R T \ln v_1 + y_1 T + \mathfrak{U}_1 + M. \qquad (4)$$

Differentiating this at constant volume,

$$\frac{d \mathfrak{A}_1}{d T} = - R \ln v_1 + y_1 + T \frac{d y_1}{d T} + \frac{d \mathfrak{U}_1}{d T} + \frac{d M}{d T} .$$

Comparing this with equation (3),

$$T \frac{d y_1}{d T} + \frac{d \mathfrak{U}_1}{d T} + \frac{d M}{d T} = 0 ; \quad \frac{d y_1}{d T} = - \frac{1}{T} \frac{d \mathfrak{U}_1}{d T} - \frac{1}{T} \frac{d M}{d T} .$$

Since $\mathfrak{U}_1$ in this case represents the internal energy of one gram-molecule, $\frac{d \mathfrak{U}_1}{d T}$ at constant volume will be equal to the molecular heat capacity, at constant volume, which may be designated by c_{v_1}. Therefore,

$$d y_1 = - \frac{c_{v_1}}{T} d T - \frac{d M}{T} .$$

Integrating,

$$y_1 = -\int_{T_0}^{T} \frac{c_{v_1}}{T} d\,T - \int_{M_{T_0}}^{M_T} \frac{d\,M}{T} + \mathfrak{J}_1,$$

where $\mathfrak{J}_1$ is the integration constant whose value depends on the value chosen for T_0 as the lower limit of integration. Substituting in equation (4), we obtain for $\mathfrak{A}_1$, the free energy, per gram-molecule, of a simple substance in any given state,

$$\mathfrak{A}_1 = -R\,T \ln v_1 - T\int_{T_0}^{T} \frac{c_{v_1}}{T} d\,T + \mathfrak{J}_1\,T + \mathfrak{M}_1 + N, \qquad (5)$$

where

$$N = M - T\int_{M_{T_0}}^{M_T} \frac{d\,M}{T},$$

and N is, like M, a quantity which will vanish in any expression for the difference in free energy at constant temperature.

From this we may obtain an equation for the change of free energy in any process. In the most general case, a system composed of any number, m_1, of different molecular constituents,* and any amount, n_1, n'_1, etc. gram-molecules of each constituent, undergoes any change, physical or chemical, arriving at a condition in which it is composed of m_2 molecular constituents, and n_2, n'_2, etc. gram-molecules of each constituent.

If $\mathfrak{A}_1$, $\mathfrak{A}'_1$, etc. represent the free energies per gram-molecule of the various simple molecular constituents, a total change in free energy will be given by the equation,

$$A = (n_1 \mathfrak{A}_1 + n'_1 \mathfrak{A}'_1 + \ldots) - (n_2 \mathfrak{A}_2 + n'_2 \mathfrak{A}'_2 + \ldots).$$

If we substitute for $\mathfrak{A}_1$, $\mathfrak{A}'_1$, etc., their values as in equation (5), the N terms will all vanish and the equation will become,

$$\begin{aligned} A = &-R\,T(n_1 \ln v_1 + n'_1 \ln v'_1 + \ldots - n_2 \ln v_2 - n'_2 \ln v'_2 - \ldots) \\ &- T\int_{T_0}^{T} \frac{n_1 c_{v_1} + n'_1 c'_{v_1} + \ldots - n_2 c_{v_2} - n'_2 c'_{v_2} - \ldots}{T} d\,T \\ &+ T(n_1 \mathfrak{J}_1 + n'_1 \mathfrak{J}'_1 + \ldots - n_2 \mathfrak{J}_2 - n'_2 \mathfrak{J}'_2 - \ldots) + (n_1 \mathfrak{M}_1 \\ &+ n'_1 \mathfrak{M}'_1 + \ldots - n_2 \mathfrak{M}_2 - n'_2 \mathfrak{M}'_2 - \ldots). \end{aligned}$$

* Molecular constituent is used to mean a single molecular species in a single phase. Thus two phases of the same molecular species are regarded as two constituents, as are two different molecular species in the same phase.

If we represent by C_{v_1} and C_{v_2} the total heat capacity, when each constituent remains at constant volume, in the initial and final states respectively; by H the total change in the various functions denoted by $n_1 \mathfrak{H}_1$, $n_2 \mathfrak{H}_2$, etc.; by U the total change in the internal energy of the system, then the equation may be written,

$$A = R\,T \ln \frac{v_2^{n_2}\, v_2'^{n'_2} \ldots}{v_1^{n_1}\, v_1'^{n'_1} \ldots} - T \int_{T_0}^{T} \frac{C_{v_1} - C_{v_2}}{T}\, d\,T + H\,T + U. \qquad (6)$$

We have in this equation *a perfectly general expression for the change of free energy in any isothermal change, chemical or physical, in any system, whether homogeneous or heterogeneous.* The quantities contained in the equation are all capable of direct experimental determination with the exception of the quantity H, of which we only know that it is not a function of the temperature, since it enters as the difference between a number of integration constants each of which is independent of the temperature. The value of this function and the simple form that it assumes in many important cases of equilibrium will be considered later.

The form which equation (6) takes in the simple cases where all the molecular species participating in the reaction are gases and dilute solutions may be shown as follows.

Equation (5), applying to the free energy of one of the simple constituents of a system, is,

$$\mathfrak{A} = -R\,T \ln v - T \int_{T_0}^{T} \frac{c_v}{T}\, d\,T + \mathfrak{H}\,T + \mathfrak{U} + N,$$

differentiated with respect to volume, at constant temperature,

$$\frac{d\,\mathfrak{A}}{d\,v} = -\frac{R\,T}{v} - T \int_{T_0}^{T} \frac{d\,c_v}{d\,v}\,\frac{1}{T}\, d\,T + T \frac{d\,\mathfrak{H}}{d\,v} + \frac{d\,\mathfrak{U}}{d\,v}. \qquad (7)$$

Since $d\,\mathfrak{A}$ represents the work accomplished in a reversible change, we may write

$$d\,\mathfrak{A} = -p\,d\,v,$$

where p denotes the gas pressure or the osmotic pressure, as the case may be. Then

$$-p = -\frac{R\,T}{v} - T \int_{T_0}^{T} \frac{1}{T} \frac{d\,c_v}{d\,v}\, d\,T + T \frac{d\,\mathfrak{H}}{d\,v} + \frac{d\,\mathfrak{U}}{d\,v}. \qquad (8)$$

Now we know that in the case of perfect gases and dilute solutions the heat of free expansion and the heat of dilution respectively are zero.

Therefore $\frac{d\,\mathfrak{U}}{d\,v} = 0$; moreover, $\frac{d\,c_v}{d\,v} = 0$. This is experimentally proved in the case of gases, and may be shown in the case of solutions as follows.

$$\frac{d\,c_v}{d\,v} = \frac{d\frac{d\,\mathfrak{U}}{d\,T}}{d\,v} = \frac{d^2\,\mathfrak{U}}{d\,v\,d\,T} = \frac{d\frac{d\,\mathfrak{U}}{d\,v}}{d\,T}; \tag{9}$$

now,

$$\frac{d\,\mathfrak{U}}{d\,v} = 0; \quad \frac{d\frac{d\,\mathfrak{U}}{d\,v}}{d\,T} = 0; \quad \text{and} \quad \frac{d\,c_v}{d\,v} = 0.$$

Equation (8) becomes

$$-p = -\frac{R\,T}{v} + T\frac{d\,\mathfrak{H}}{d\,v}.$$

But since we know that $p = \frac{R\,T}{v}$ is the characteristic equation of the perfect gas and the dilute solution, $\frac{d\,\mathfrak{H}}{d\,v} = 0$.

In these two simple cases, therefore, we find that $\mathfrak{U}$, c_v, $\mathfrak{H}$, are all independent of the volume. If then, equation (6) is applied to a reaction between gases and dilute solutions, the quantities $\mathfrak{U}_1$, c_{v_1}. $\mathfrak{H}_1$; $\mathfrak{U}_2$, c_{v_2}, $\mathfrak{H}_2$, etc. will not at any given temperature change with changing volume, and the quantities U, $C_{v_1} - C_{v_2}$, H, will be constant, however the initial and final volume conditions of the system are changed. For any one temperature equation (6) may be written,

$$A = R\,T \ln \frac{v_2^{\,n_2} v_2'^{\,n'_2} \ldots}{v_1^{\,n_1} v_1'^{\,n'_1} \ldots} + C \text{ (a constant)}. \tag{10}$$

This equation, moreover, obviously applies to any system which contains, besides gases and dilute solutions, any constituents participating in the reaction, whose molecular volume is not changed appreciably by a change in the conditions of volume or pressure in the system. Thus any solid phase of definite constitution in a heterogeneous system may be considered constant in its molecular volume, as well as in its functions $\mathfrak{U}$, C_v, $\mathfrak{H}$, when the pressure of the system is varied through limits not too wide.

Since equation (6) gives an expression for the change of free energy in any isothermal process, we may derive immediately a general equation for equilibrium in any system. Let us consider a system such as is ordinarily studied, upon which the only external force is a uniform pressure,

normal to the surface, and in which the effects of gravity, surface tension, etc. may be neglected.

A necessary and sufficient condition for equilibrium is, that any change in a system in equilibrium is reversible. In other words, the change in the free energy of the system must be equal to the external work.*

In the case under consideration the external work is the product of the external pressure, P, by the change, V, in the volume of the system. Therefore in equilibrium,

$$A = P V. \tag{11}$$

Let us consider a system, of any degree of complexity, which is capable of change. In general this change will consist in a loss by some constituents of the system, accompanied by a corresponding gain by others. Then according to equation (6),

$$A = R T \ln \frac{v_2^{n_2} v_2'^{n'_2} \dots}{v_1^{n_1} v_1'^{n'_1} \dots} - T \int_{T_0}^{T} \frac{C_{v_1} - C_{v_2}}{T} d T + H T + U,$$

where quantities with subscript 1 refer to the constituents which suffer loss; those with subscript 2, to those which gain, and n_1, n'_1, etc., and n_2, n'_2, etc. represent the number of gram-molecules of each constituent lost and gained respectively.

Combining equations (6) and (11) we have as the general equation of equilibrium,

$$P V = R T \ln \frac{v_2^{n_2} v_2'^{n'_2} \dots}{v_1^{n_1} v_1'^{n'_1} \dots} - T \int_{T_0}^{T} \frac{C_{v_1} - C_{v_2}}{T} d T + H T + U, \tag{11 a}$$

where P is the external pressure and V is the total change in volume.

$$V = (n_2 v_2 + n'_2 v'_2 + \dots) - (n_1 v_1 + n'_1 v'_1 + \dots).$$

This equation (11 a) expresses the equilibrium of the system in regard to the particular change in question. When a system is in perfect equilibrium there will be an equation of the above form for every change or reaction which can take place independently. These equations, however, will not all be independent. For example, if both liquid and gaseous acetic acid are composed of two kinds of molecules, namely, CH_3COOH and $(CH_3COOH)_2$, then when acetic acid and its vapor are in equilib-

* Of course the change must not be great enough to disturb the condition of equilibrium. The following demonstration would be somewhat more rigorous if the infinitesimal notation were used.

rium, we have four equations of the type of (11 *a*); one referring to the equilibrium in the gaseous state of the reaction, $2\,CH_3COOH = (CH_3COOH)_2$; another, referring to the same reaction in the liquid phase; a third, referring to the liquefaction or vaporization of the double molecules; the fourth, to the liquefaction or vaporization of the single molecules. Of these four equations three are independent.

Returning to the discussion of the general equation of equilibrium, equation (11 *a*), it is interesting first to determine what form it will take when we limit the system considered to the conditions under which equation (10) was deduced, namely, that the reacting system shall include, besides gases and dilute solutions, only "condensed" phases of definite composition. Combining equations (10) and (11),

$$P\,V = R\,T \ln \frac{v_2^{n_2} v_2'^{\,n'_2} \ldots}{v_1^{n_1} v_1'^{\,n'_1} \ldots} + C.$$

Now V, the change of volume, is due in this case to the change in volume of the gaseous constituents, and will therefore, at constant temperature, be inversely proportional to P. Therefore $P\,V$ is a constant, and at constant temperature,

$$\ln \frac{v_2^{n_2} v_2'^{\,n'_2} \ldots}{v_1^{n_1} v_1'^{\,n'_1} \ldots} = C', \quad \text{and} \quad \frac{v_2^{n_2} v_2'^{\,n'_2} \ldots}{v_1^{n_1} v_1'^{\,n'_1} \ldots} = K \text{ (a constant).} \qquad (12)$$

This equation is the familiar mass law of Guldberg and Waage, but it is also, since it is not restricted to homogeneous systems, the law of the constancy of the ratio of distribution among different phases. This includes the law of Henry.

That equation (12) does not represent a universally accurate law of nature is shown by comparison with equation (11 *a*); for it is only when U, H, $C_{v_1} - C_{v_2}$, and $P\,V$ are constant that $\dfrac{v_2^{n_2} v_2'^{\,n'_2} \ldots}{v_1^{n_1} v_1'^{\,n'_1} \ldots}$ is constant. If this fraction for convenience is denoted by K, which may be called, instead of the equilibrium constant, the equilibrium ratio, then K is a function, not only of the temperature, but also of U, H, C_{v_1}, C_{v_2}, $P\,V$. The nature of this function may be shown from equation (11 *a*),

$$R\,T \ln K = P\,V - U + T\int_{T_0}^{T} \frac{C_{v_1} - C_{v_2}}{T}\, d\,T - HT; \qquad (13)$$

$$\ln K = \frac{1}{R}\left(\frac{P\,V}{T} - \frac{U}{T} + \int_{T_0}^{T} \frac{C_{v_1} - C_{v_2}}{T}\, d\,T - H\right); \qquad (14)$$

$$K = e^{\frac{1}{R}\left(\frac{PV}{T} - \frac{U}{T} + \int_{T_0}^{T}\frac{C_{v_1} - C_{v_2}}{T}dT - H\right)}, \tag{15}$$

in which e is the base of the natural system of logarithms.

From this general equation of equilibrium may be easily deduced the expression for the change of the conditions of equilibrium with change of temperature. In equation (14) let, for convenience,

$$\int_{T_0}^{T}\frac{C_{v_1} - C_{v_2}}{T}dT - H = F, \tag{16}$$

equation (14) differentiated with respect to temperature then becomes

$$\frac{d\ln K}{dT} = \frac{1}{R}\left[\frac{d\left(\frac{PV}{T}\right)}{dT} - \frac{1}{T}\frac{dU}{dT} + \frac{U}{T^2} + \frac{dF}{dT}\right]. \tag{17}$$

Now F is a function of T and also of $\ln K$, which is itself a function of T. According to the laws of partial derivatives,

$$\frac{dF}{dT} = \frac{\delta F}{\delta T} + \frac{\delta F}{\delta \ln K}\frac{d\ln K}{dT},$$

where δ signifies a partial differential. Since H is independent of the temperature, and

$$F = \int_{T_0}^{T}\frac{C_{v_1} - C_{v_2}}{T}dT - H,$$

then,

$$\frac{\delta F}{\delta T} = \frac{C_{v_1} - C_{v_2}}{T} = \frac{1}{T}\frac{dU}{dT}, \quad \text{for} \quad C_{v_1} - C_{v_2} = \frac{dU}{dT}.$$

Therefore,

$$\frac{dF}{dT} = \frac{1}{T}\frac{dU}{dT} + \frac{\delta F}{\delta \ln K}\frac{d\ln K}{dT},$$

and equation (17) becomes

$$\frac{d\ln K}{dT} = \frac{1}{R}\left[\frac{d\left(\frac{PV}{T}\right)}{dT} - \frac{1}{T}\frac{dU}{dT} + \frac{U}{T^2} + \frac{1}{T}\frac{dU}{dT} + \frac{\delta F}{\delta \ln K}\frac{d\ln K}{dT}\right],$$

and by transposition

$$\frac{d\ln K}{dT}\left(1 - \frac{1}{R}\frac{\delta F}{\delta \ln K}\right) = \frac{1}{R}\left[\frac{d\left(\frac{PV}{T}\right)}{dT} + \frac{U}{T^2}\right] \tag{18}$$

If we consider the special case of a system whose volume is unchanged by the reaction to which the equilibrium equation refers, then $V = 0$, and

$$\frac{d \ln K}{d T}\left(1 - \frac{1}{R}\frac{\delta F}{\delta \ln K}\right) = \frac{U}{R T^2}. \tag{19}$$

F, since it is equal to $\int_{T_0}^{T} \frac{C_{v_1} - C_{v_2}}{T} d T - H$, was shown to be constant under the conditions which led to equations (10) and (12), when the conditions of equilibrium changed at constant temperature. In such cases, therefore, $\frac{\delta F}{\delta \ln K} = 0$, and the equation becomes

$$\frac{d \ln K}{d T} = \frac{U}{R T^2}. \tag{20}$$

This equation applies to both homogeneous and heterogeneous equilibrium. When applied to the former it is identical with the well known equation of van't Hoff, sometimes called the equation "isochore." This equation, however, has been used to express the change of equilibrium with the temperature, not merely in those systems in which the reaction causes no change in volume, but in general. That this use is justifiable in the cases for which equation (20) was developed may be readily shown. For, in systems subject to moderate pressure, the only considerable isothermal changes in volume are those of the gaseous phase. The volume of the gases is, at a given pressure and temperature, proportional to the total number of gram-molecules of the various gases present. If, during the reaction to which the equation refers, there is a change of n gram-molecules in the gaseous phase, then the total change in volume is,

$$V = \frac{n R T}{P}, \quad \text{or} \quad \frac{P V}{T} = n R.$$

In the case under discussion, where $\frac{\delta F}{\delta \ln K} = 0$, equation (18) may be written,

$$\frac{d \ln K}{d T} = \frac{1}{R}\left(\frac{d\left(\frac{P V}{T}\right)}{d T} + \frac{U}{T^2}\right).$$

Since $\frac{P V}{T} = n R$, a constant,

$$\frac{d \ln K}{d T} = \frac{U}{R T^2}.$$

Similarly, for any system in general in which the pressure is not very great, $d\left(\frac{PV}{T}\right)$ will be negligible, and, for a very close approximation, equation (18) becomes

$$\frac{d \ln K}{d\,T}\left(1 - \frac{1}{R}\frac{\delta F}{\delta \ln K}\right) = \frac{U}{R\,T^2}. \tag{21}$$

Comparing equations (20) and (21), we see that the conditions under which the above law of van't Hoff holds true are practically the same as those under which the equation "isotherm" of the mass law, equation (12), is true; namely, that F, and therefore $C_{v_1}' - C_{v_2}$ and H are, at constant temperature, independent of the volume conditions of the system.

The various equations which have been here deduced from the general equations of free energy and equilibrium can be best studied further by their application to special cases of equilibrium, which we will proceed to discuss somewhat systematically.

II. Application to Monomolecular Systems.

(*A.*) *Homogeneous Systems.*

1. *Gases.* — The simplest conceivable case of physico-chemical equilibrium is offered by a single molecular species in a single phase in equilibrium with the external pressure. For this case the equation of condition has already been found, — equation (8), namely,

$$p = \frac{R\,T}{v} + T\int_{T_0}^{T}\frac{1}{T}\frac{d\,c_v}{d\,v}\,d\,T - T\frac{d\,\mathfrak{H}}{d\,v} - \frac{d\,\mathfrak{U}}{d\,v}.$$

In the case of a perfect gas it has been shown that

$$\frac{d\,c_v}{dv} = 0;\ \ \frac{d\,\mathfrak{H}}{dv} = 0;\ \ \frac{d\,\mathfrak{U}}{d\,v} = 0;\ \ \text{and}\ \ p = \frac{R\,T}{v}. \tag{22}$$

The next case that deserves attention is that of a compressed gas. Here, also, the specific heat at constant volume is independent of the volume. This has been shown to be true up to pressures of several thousand atmospheres.* A recent work has questioned the absolute accuracy of this law. We will return to this point later. Meanwhile we may consider $\frac{d\,c_v}{d\,v} = 0$, and equation (8) then simplifies to

* Mallard and Le Chatelier, Wied.-Beibl., XIV. 364.

$$p = \frac{R\,T}{v} - T\frac{d\,\mathfrak{N}}{dv} - \frac{d\,\mathfrak{U}}{dv}. \qquad (23)$$

From equation (9), since $\frac{a\,c_v}{d\,v} = 0$, $\frac{d\left(\frac{d\,\mathfrak{U}}{d\,v}\right)}{d\,T} = 0$, and therefore the term $\frac{d\,\mathfrak{U}}{d\,v}$ is independent of the temperature when c_v is independent of the volume. This term represents the heat developed in the free expansion of a gas, and shows that when the internal energy of a gas increases with increasing volume, — that is, when there is a cooling effect on free expansion, — the gas will have lower than normal pressure.

Since $\frac{d\,\mathfrak{N}}{d\,v}$ is a function of the volume alone, we may write equation (23) in the form,

$$p = \left(\frac{R}{v} - F(v)\right)T - \frac{d\,\mathfrak{U}}{d\,v}. \qquad (24)$$

And since $\frac{d\,\mathfrak{U}}{d\,v}$ is not a function of the temperature, the equation of a gas at constant volume, the "isochore," is,

$$p = A\,T - B, \quad \text{where } A \text{ and } B \text{ are constants.} \qquad (25)$$

This equation has been proved experimentally by Ramsay and Young.*

The values of $\frac{d\,\mathfrak{U}}{d\,v}$ for a few gases may be found from the porous plug experiments of Joule and Thomson. These experimenters determined directly, not $\frac{d\,\mathfrak{U}}{d\,v}$, but $\frac{d\,\mathfrak{U}}{d\,p}$, and found that in all their experiments with a variety of gases and mixtures of gases that the latter quantity was independent of the actual pressure of the experiment. That is, at constant temperature $\frac{d\,\mathfrak{U}}{d\,p}$ is a constant. We may write

$$d\,v = -\frac{v^2}{R\,T}dp$$

from the gas law, neglecting the errors introduced by the deviations from this law, which are of much smaller order than the errors of the experimental results that we are using. Then,

* Zeit. Phys. Chem., I. 433.

$$\frac{d\,\mathfrak{A}}{dv} = -\frac{R\,T}{v^2}\frac{d\,\mathfrak{A}}{dp}. \tag{26}$$

We may now write for equation (24),

$$p = \left(\frac{R}{v} - F(v)\right) T + \frac{R\,T}{v^2}\frac{d\,\mathfrak{A}}{dp}.$$

Now, for reasons that will be obvious immediately, we will write with perfect generality in place of $\frac{R}{v} - F(v)$, $\frac{R}{v - f(v)}$, where $F(v)$ and $f(v)$ are different functions of v. Then,

$$p = \frac{R\,T}{v - f(v)} + \frac{R\,T}{v^2}\frac{d\,\mathfrak{A}}{dp}. \tag{27}$$

Now since the last term is independent of the temperature, $\frac{d\,\mathfrak{A}}{dp} R\,T$ must be independent of the temperature. But since $\frac{d\,\mathfrak{A}}{dp}$ is constant at constant temperature, $R\,T\frac{d\,\mathfrak{A}}{dp}$ is also independent of the volume. This quantity, therefore, is constant under all conditions to which the system is subjected. Let us write, $-R\,T\frac{d\,\mathfrak{A}}{dp} = a$, and we obtain,

$$p = \frac{R\,T}{v - f(v)} - \frac{a}{v^2}. \tag{28}$$

This equation, which is identical with the familiar formula that van der Waals has developed from purely kinetic considerations, is here shown to be directly deducible from a general thermodynamic equation, with the aid of two simple empirical observations, namely, the constancy of the specific heat of gases at constant temperature, and the proportionality between the cooling effect and the fall in pressure in the free expansion of gases.

Equation (28) does not define the nature of $f(v)$, and in this respect is less explicit than the corresponding term in the equation of van der Waals, which is a constant, b. Nevertheless it must be borne in mind that b, the volume correction in the formula of van der Waals, may only be regarded as constant when the volume is large, and that it also is in reality an undetermined function of the volume.

The constancy of the quantity, $R\,T\dfrac{d\,\mathfrak{U}}{d\,p}$ or a, we have only proved in the cases of the gases which were experimented upon by Joule and Thomson, and through limited range of pressure. However, since the constancy of this term was established for all the gases tried, we may assume that the same result would have been obtained with any other gases through the same limits of pressure. It cannot be taken for granted that this constancy will hold at all pressures. In fact, the interpretation given by van der Waals for the quantity a, as the intermolecular attraction, would lead to the idea that it must be a function of the volume. Otherwise the attraction between two molecules would be independent of their distance apart. The variation of a with the volume will be mentioned later.

Van der Waals considered *a priori* that a would not depend upon the temperature. But it is evident from page 14 that it is a constant only if $\dfrac{d\,c_v}{d\,v} = 0$. Although the change of specific heat with moderate change of volume is negligible, the change through wide limits of volume is probably always a measurable quantity, as will be shown later.

Since the quantity a has been defined as equal to $-R\,T\dfrac{d\,\mathfrak{U}}{d\,p}$, we should be able to determine its value from the data of Joule and Thomson. A calculation which is in effect the same as this has already been made by van der Waals,* who calculated from the values of a and b, given by experiment, the cooling effect that should be observed in free expansion. This cooling effect, in Centigrade degrees, for a change of one atmosphere in pressure is given below, as calculated by van der Waals and as determined by the averages of Joule and Thomson's results: —

	Temp. Cels.	Calculated.	Observed.
Air	17	0.265	0.259
"	90	0.18	0.206
CO_2	18	0.9	$1.\dot{1}5$
"	91.5	0.64	0.703

The agreement, although not close, is very satisfactory considering the uncertainty of the experimental results.

2. *Liquids.* — The experimental proof of the continuity between the liquid and gaseous states shows that we must regard them as identical,

* Kontinuität der F. und G. Zustand, p. 116.

and any formula that is universally applicable to one state must also be applicable to the other. Thus all the equations already developed for gases apply without change to simple liquids (having a constant molecular weight) under the restrictions already mentioned, namely, that in the equations

$$p = \frac{R\,T}{v - f(v)} - \frac{d\,\mathfrak{A}}{d\,v} \quad \text{and} \quad p = \frac{R\,T}{v - b} - \frac{a}{v^2},$$

$\frac{d\,\mathfrak{A}}{d\,v}$ and $\frac{a}{v^2}$ are independent of the temperature only when $\frac{d\,c_v}{d\,v} = 0$, that a has not been proved to be a constant in all cases but may be a function of the volume, and that b is not necessarily a constant with changing volume, although it is in all cases independent of the temperature.

Regarding the question of the variability of c_v with the volume in the case of liquids we have no direct experimental evidence, but indirectly it can be shown that c_v is practically constant, for Ramsay and Young (page 14) found that equation (25), $p = A\,T - B$, applies to liquids as well as to gases, and this equation can only be true when $\frac{d\,c_v}{d\,v} = 0$.*

If $\frac{d\,c_v}{d\,v}$ is not equal to zero, then the general equation (8) must be used,

$$p = \frac{R\,T}{v} - T\frac{d\,\mathfrak{P}}{d\,v} - \frac{d\,\mathfrak{A}}{d\,v} + T\int_{T_0}^{T} \frac{1}{T}\,\frac{d\,c_v}{d\,v}\,d\,T;$$

this, differentiated with respect to T, v constant, gives

$$\frac{d\,p}{d\,T} = \frac{R}{v} - \frac{d\,\mathfrak{P}}{d\,v} - \frac{d^2\,\mathfrak{A}}{d\,v\;d\,T} + \int_{T_0}^{T} \frac{1}{T}\,\frac{d\,c_v}{d\,v}\,d\,T + \frac{d\,c_v}{d\,v}.$$

Since $\frac{d^2\,\mathfrak{A}}{d\,v\;d\,T} = \frac{d\,c_v}{d\,v}$ from equation (9),

$$\frac{d\,p}{d\,T} = \frac{R}{v} - \frac{d\,\mathfrak{P}}{d\,v} + \int_{T_0}^{T} \frac{1}{T}\,\frac{d\,c_v}{d\,v}\,d\,T = C + \int_{T_0}^{T} \frac{d\,c_v}{d\,v}\,\frac{d\,T}{T}, \qquad (29)$$

where C is a constant; while from equation (25) $\frac{d\,p}{d\,T} = A$.

Notwithstanding this evidence for the approximate constancy of the specific heat, the experimental work of Joly † on this subject seems to

---

* Compare Nernst, Theor. Chem., p. 202.

† Phil. Trans. Roy. Soc., 182A, 73; Proc. Roy. Soc., XLVII. 218; LV. 390.

show that the value of c_v in a gas does change considerably through wide limits of volume. He has been the first to succeed in measuring directly the specific heat of gases at constant volume. The values were determined by means of his differential steam calorimeter, a method which seems to give very accurate and consistent results. The results showed that the specific heat at constant volume could be expressed in the following formulæ,

$$\text{For Air,} \quad c_v = .17151 + .02788\,\rho,$$
$$\text{For } CO_2, \quad c_v = .1650 + .2125\,\rho + .3400\,\rho^2,$$

where ρ is the density in grams per cubic centimeter. According to these formulæ the specific heat at constant volume at atmospheric pressure differs from that at infinite volume by only two hundredths of one per cent in the case of air, and by three tenths of one per cent in the case of carbon dioxide. Between the specific heats of the gases at atmospheric pressure and in a highly compressed or liquid condition the change is much greater. For example, the value given by the formula for c_v in the case of carbon dioxide is about twice as great at the critical volume and about three and one half times as great in the liquid at 0° C. as the value for the gas at ordinary pressure. Further evidence of the change of c_v between the liquid and gaseous condition will be given later.

In these variations in the specific heat we find the probable cause of many of the deviations from the equation of van der Waals that have been noticed. It may be found necessary, therefore, in order to obtain a more exact equation of condition, to return to the more general equation (8),

$$p = \frac{R\,T}{v} + T\int_{T_0}^{T}\frac{1}{T}\,\frac{d\,c_v}{d\,v}\,d\,T - T\frac{d\,\mathfrak{H}}{d\,v} - \frac{d\,\mathfrak{A}}{d\,v},$$

in which the value of $\frac{d\,\mathfrak{H}}{d\,v}$ contains not only the function for volume correction, but also a term depending upon the value chosen for the lower limit of integration, T_0. If we write

$$\frac{d\,\mathfrak{H}}{d\,v} = F(v), \quad \text{then} \quad \frac{R\,T}{v} - F(v)\,T = \frac{R}{v - f(v)}T - F'(v)\,T,$$

where $f(v)$ denotes the same function of v that has been used in equations (27) and (28), namely, the quantity b in the van der Waals formula, and $F'(v)$, another function of v. Now $\frac{d\,c_v}{d\,v}$ is practically independent of the temperature and the equation may be written

$$p = \frac{R\,T}{v - f(v)} - T \ln \frac{T}{T_0}\,\frac{d\,c_v}{d\,v} - F'(v)\,T - \frac{d\,\mathfrak{A}}{d\,v}.$$

It is probable from the derivation of $F'(v)$ that this is a function of the same general nature as the preceding term, and will vary with the volume in the same way that $\frac{d\,c_v}{d\,v}$ does. Then, since the coefficient of $\frac{d\,c_v}{d\,v}$ is not a volume function, we may write, not as a complete expression, but as an approximation one step nearer the truth than the equations previously obtained, the following isothermal equation of condition,

$$p = \frac{R\,T}{v - f(v)} - \frac{d\,\mathfrak{A}}{d\,v} + c\,\frac{d\,e_v}{d\,v}, \tag{30 a}$$

or, after the type of the van der Waals equation,

$$p = \frac{R\,T}{v - b} - \frac{a}{v^2} + c\,\frac{d\,c_v}{d\,v}, \tag{30 b}$$

where c is a third constant to be determined by experiment, and which differs with different temperatures.

Equation (29) gives the corresponding equation isochore, which may be written for moderate ranges of temperature,

$$\frac{d\,p}{d\,T} = C - \frac{d\,c_v}{d\,v} \ln T. \tag{31}$$

These equations, (30) and (31), should furnish a more exact statement of the behavior of gases and liquids than the equation of van der Waals or the corresponding ones developed in this paper. Since the degree of accuracy is not known in the values of $\frac{d\,c_v}{d\,v}$ at present determined, I have not yet attempted an application of these equations.

Returning to the consideration of $f(v)$ or b, it may be stated at once that this quantity is always a function of the volume and decreases with decreasing volume, for usually the total volume in the liquid state is less than b calculated for the gaseous state, and if b were constant then $v - b$ would have a negative value, which would be meaningless. $v - b$ must always have a positive value.

The way in which the quantity a varies with the volume cannot be predicted. If it represents the attraction between the molecules, then it will vary inversely with the volume if the attraction between the molecules varies inversely with the distance. But since the attraction observed is probably the resultant of forces attractive and repulsive acting between

the molecules, we cannot say *a priori* how it will change with the distance between the molecules. In fact it is not necessary to suppose that a or $\frac{d\mathfrak{A}}{dv}$ must always have a positive value. Joule and Thomson found in the case of hydrogen a rise of temperature instead of the usual cooling effect on free expansion. This would indicate a small negative value of a, corresponding to a preponderance of repulsive force between the molecules. The unreliability of the experimental data, however, precludes certainty on this point.

In place of the equation

$$p = \frac{R\,T}{v - f(v)} - \frac{d\mathfrak{A}}{d\,v}, \qquad\qquad p = \frac{R\,T}{v - b} - \frac{a}{v^2},$$

the equation of van der Waals, can be applied to liquids with the understanding that a and b are not constants but volume functions to be determined. In all liquids p is small compared with the other two terms. When $p = 0$, if we represent the volume by v_0,

$$\frac{R\,T}{v_0 - b} = \frac{a}{v_0{}^2}; \tag{32}$$

but since the volume of liquids is only slightly changed by changing the external pressure, $v_0 - b$ will not differ materially from $v - b$ at atmospheric pressure. We may write, then, as the equation for liquids at atmospheric pressure,

$$\frac{R\,T}{v - b} = \frac{a}{v^2}. \tag{33}$$

From this equation may be found the values of a and b when the volume of a liquid is known at two different temperatures. From the values thus found it should be theoretically possible to calculate the compressibility of the liquid at constant temperature. Thus by differentiating the van der Waals equation we obtain the reciprocal of the compressibility,

$$\frac{d\,p}{d\,v} = -\frac{R\,T}{(v - b)^2} + 2\frac{a}{v^3};$$

practically this method fails on account of the fact that the difference between the last two terms is very small compared with their total values, and therefore any error in either of these terms is multiplied enormously in the determination of $\frac{d\,p}{d\,v}$.

The values of a and b obtained from equation (33) will be of service

later in discussing certain relations between the liquid and gaseous state. The way in which a and b change with varying conditions of a liquid is illustrated by the following values, calculated for fluor-benzol, from the data given by Young.* For the values at high pressures p is not negligible compared with $\frac{a}{v^2}$, equation (33) will not give exact results, and recourse must be had to the original equation of van der Waals. v represents molecular volume in litres, p is expressed in atmospheres, and b and a in units corresponding.

	v	b	a
	.097	.00075	11.6
	.111	.00078	12.8
	.127	.00081	13.5
	.157	.00088	15.0
	.225	.00110	17.9
	.232	.00114	18.2
By extrapolation from these values we find for $v = .270$ the critical volume	.270	.00126	19.7
From the critical data a and b are determined to be	.270	.00128	19.9

It is evident that the values of a and b obtained from the data for the thermal expansion of a liquid are entirely consistent with those determined from the critical data. The change of b with the volume is well shown by the figures, and is typical. Regarding the variation in a, however, it is not possible to say whether it is due to change in volume or change in temperature, or both.

It must be emphasized that in all the preceding work on gases and liquids we are dealing with substances composed of a single molecular species. Gases and liquids in which dissociation or association occur are not within the scope of this section.

(B.) *Heterogeneous Systems.*

1. *Gases and Liquids.* — The simplest case of heterogeneous equilibrium in a system composed of a single molecular species is that between a simple liquid and its vapor. We may apply to this case the general equation of equilibrium (11 a). If we consider the specific heat at con-

* Phil. Mag., XXXIII. 153.

stant volume the same in the liquid and its vapor, the equation assumes the simpler form

$$R\,T \ln \frac{v_2}{v_1} = P\,V - U - H\,T, \tag{34}$$

where v_1 and v_2 represent the molecular volumes in the liquid and gaseous states respectively. From the previous section we know that the term H will enter simply as a volume correction. The exact manner in which it so enters may be best shown by finding the free energy of the process of liquefaction from the work that might be done if the vapor were compressed isothermally and continuously until it reached the liquid condition. This work would be equal to $\int p\,dv$, and p can be found in terms of v from the equation of condition which holds good throughout the process. From equation (27)

$$p = \frac{R\,T}{v - f(v)} - \frac{d\,\mathfrak{A}}{d\,v}.$$

Therefore

$$A = \int_{v_2}^{v_1} p\,dv = \int_{v_2}^{v_1} \frac{R\,T}{v - f(v)}\,d\,v - \int_{v_2}^{v_1} d\,\mathfrak{A}.$$

The integration of $\dfrac{R\,T}{v - f(v)}\,d\,v$ is only possible when the form of $f(v)$ is known; but since $f(v)$ does not change greatly, and since it is only an important part of the expression when v is small, it may be regarded as a constant, and equal to the value of $f(v)$ in the liquid state, or b_1. This value may be found from equation (33). Then the above equation becomes

$$A = R\,T \ln \frac{v_2 - b_1}{v_1 - b_1} + U,$$

and for equilibrium from equation (11), $A = P\,V$.

$$R\,T \ln \frac{v_2 - b_1}{v_1 - b_1} = P\,V - U. \tag{35}$$

Since b_1 is but small compared with v_2, we may replace $v_2 - b_1$ by v_2. Since U represents the change of internal energy in vaporization, and $P\,V$ the external work, $-U + P\,V$ will be equal to the ordinary heat of vaporization per gram-molecule, including the external work. This whole quantity may be designated by L. Then

$$R\,T \ln \frac{v_2}{v_1 - b_1} = L. \tag{36}$$

This equation of equilibrium, which is at the same time a simple formula for the heat of vaporization, has been deduced for all cases in which there is no change in the molecular weight or in the specific heat at constant volume during vaporization. Let us, in the following table, compare for a few substances the experimentally determined values of L with those calculated from equation (36).

R is in such units that L will be in gram-calories, and equals 1.98. The values of b_1 are obtained from the coefficient of thermal expansion of the liquid by equation (33). For the value of v_2, the molecular volume of the vapor, in the cases in which they have not been experimentally determined, I have used the volume which a gram-molecule of a perfect gas would have under the same conditions. The error thus introduced will be negligible, for a large error in v_2 or in $v_1 - b_1$ will affect only slightly the value of L.

	Temp. C.	v_1	b_1	v_2	L (calc.)	L (obs.)
Ether	35	.1062 *	.080	24.82	4,200	6,600 §
Benzol	80	.096 †	.065	28.87	4,800	7,200 ‖
Methyl formiate .	40	.0627 ‡	.047	25.02 ‡	4,500	6,900 ¶
Methyl propionate	80	.1047 ‡	.077	27.50 ‡	4,800	7,400 **

The results are very interesting, the calculated values being in each case about two thirds of the observed. The explanation of the lack of agreement must lie in the failure of the substances to comply with the conditions named above. We have no reason to suspect, in the case of all these substances, the polymerization of the molecules in the liquid state. We are therefore again led to the belief that the specific heat at constant volume is, in general, different in the liquid and gaseous states. Moreover, I think that it is possible to show this in another, entirely independent way. The specific heat at constant pressure of a substance is the sum of two quantities, one representing the internal change in energy and the other the external, that is,

$$c_p = \left(\frac{d\,\mathfrak{E}}{d\,T}\right)_p + P\left(\frac{d\,v}{d\,T}\right)_p, \tag{37}$$

* Kopp: Jahresber. der Chem., 1860.
† Pisati, Paterno: Jahresber., 1874.
‡ Young, Thomas: Phil. Mag., XXXIV. 508.
§ Brix: Pogg. Ann., LV. 341.
‖ Wirtz: Wied. Ann., XL. 438.
¶ For 32.9°, Andrews: Pogg. Ann., LXXV. 501.
** Schiff: Lieb. Ann., CCXXXIV. 338.

where $\left(\frac{d\mathfrak{E}}{dT}\right)_P$ and $\left(\frac{dv}{dT}\right)_P$ represent the change of internal energy and volume respectively, with a change of temperature at constant pressure, P.

$$\left(\frac{d\mathfrak{E}}{dT}\right)_P = \left(\frac{d\mathfrak{E}}{dT}\right)_v + \left(\frac{d\mathfrak{E}}{dv}\right)_T \left(\frac{dv}{dT}\right)_P,$$

$$\left(\frac{d\mathfrak{E}}{dT}\right)_v = c_v,$$

$$c_v = \left(\frac{d\mathfrak{E}}{dT}\right)_P - \left(\frac{d\mathfrak{E}}{dv}\right)_T \left(\frac{dv}{dT}\right)_P;$$

from (37),

$$\left(\frac{d\mathfrak{E}}{dT}\right)_P = c_P - P\left(\frac{dv}{dT}\right)_P,$$

$$c_v = c_P - \left(\frac{dv}{dT}\right)_P \left(\frac{d\mathfrak{E}}{dv}\right)_T - P\left(\frac{dv}{dT}\right)_P,$$

$$c_v = c_P - \left(\frac{dv}{dT}\right)_P \left[P + \left(\frac{d\mathfrak{E}}{dv}\right)_T\right]. \tag{38}$$

We have found for a gas or a liquid, $\frac{d\mathfrak{E}}{dv} = \frac{a}{v^2}$. Substituting in (38),

$$c_v = c_P - \left(\frac{dv}{dT}\right)_P \left(P + \frac{a}{v^2}\right). \tag{39}$$

Since $\left(\frac{dv}{dT}\right)_P$ is the measure of thermal expansion, equation (39) contains only quantities capable of experimental determination, and we are able to calculate c_v from the experimentally found value of c_P. The calculation is further simplified by the fact that in the case of most vapors $\frac{a}{v^2}$ is negligible compared with P, and in liquids P is negligible compared with $\frac{a}{v^2}$. For close approximations, therefore, we may write for liquids,

$$c_v = c_P - \frac{a}{v^2}\left(\frac{dv}{dT}\right)_P; \tag{40 a}$$

and for vapors,

$$c_v = c_P - P\left(\frac{dv}{dT}\right)_P = c_P - R, \tag{40 b}$$

that is, the equation for the specific heats of perfect gases applies to

vapors in which $\frac{a}{v^2}$ is negligible compared with the atmospheric pressure.

The molecular specific heats at constant pressure of ether in the liquid and gaseous states are 40.48 and 31.67 respectively. At 30 degrees, the coefficient of thermal expansion for the liquid is .000163; $v = .1054$ litres; a, calculated by means of equation (33), in such units that $\frac{a}{v^2}$ is in atmospheres, is equal to 10.84. From these data $\frac{a}{v^2}\left(\frac{d\,v}{d\,T}\right)_p = .1590$ in litre-atmospheres, or 3.843 in gram-calories. Subtracting the latter value from 40.48, we obtain 36.64 as the molecular specific heat at constant volume of liquid ether. From the value 31.67, subtracting the value of R, 1.98, we obtain 29.69 as the molecular specific heat at constant volume of ether vapor. The difference between these values is far greater than could be explained by experimental errors.

It is interesting to see whether an explanation of such variations in specific heat at constant volume can be found from the kinetic point of view. We must believe that the energy imparted to a substance for an increase in the progressive motion of its molecules corresponding to a definite rise in temperature must be independent of the conditions of the substance. If, however, the heat energy of a body is due not only to the progressive motion of its molecules, but also to some additional motion such as the vibration or rotation of molecules, then the energy given to the body in raising its temperature would be in part used in increasing the progressive motion and in part in increasing the secondary motions of vibration, rotation, etc. The quantity of energy required for the latter would not necessarily be independent of the volume of the body, but might depend upon the proximity or rate of collision of the molecules. If, however, a body were composed of molecules incapable of any except progressive motion, we should predict absolute constancy in the specific heat at constant volume. Mercury vapor is believed to be such a body, and if liquid mercury, as seems probable, also is composed of monatomic molecules, the value of c_v in the two states should be identical. Unfortunately the specific heat of mercury vapor is unknown, and we cannot test the correctness of this supposition directly. But if it be true, equation (36) should give a correct result for the heat of vaporization of mercury. A calculation similar to those whose results appear on page 23 gives, for $T = 623$, $v_1 = .01566$, $b_1 = .01419$, $v_2 = 58.7$, $L = 13{,}070$. The value experimentally observed by Person (1846) was 12,400.*

* Comptes Rendus, XXIII. 162 *et seq.*

The agreement is satisfactory and within the limits of experimental error.

2. *The Vapor Pressure Curve.* — The change with changing temperature of the equilibrium between a vapor and its liquid or solid phase may be obtained from equation (20); for if we consider the vapor to obey with sufficient exactness the laws of perfect gases, the system under consideration is one for which equation (20) was developed, since it contains only a gaseous phase and a condensed phase of definite composition.

From equation (20), $$\frac{d \ln K}{d T} = \frac{U}{R T^2}.$$

$$\ln K = \ln v - \ln v',$$

where v is the molecular volume of the vapor, v' that of the solid or liquid. $\frac{d \ln v'}{d T}$ is entirely negligible compared with $\frac{d \ln v}{d T}$, and equation (20) becomes

$$\frac{d \ln v}{d T} = \frac{U}{R T^2}.$$

Since $v = \frac{R T}{p}$, where p is the vapor pressure,

$$\ln v = - \ln p + \ln R + \ln T,$$

and $$d \ln v = - d \ln p + \frac{1}{T} d T.$$

Substituting, $$\frac{d \ln p}{d T} = - \frac{U}{R T^2} + \frac{1}{T} = \frac{- U + R T}{R T^2}.$$

As on page 22, let $- U + R T = L$,

then $$\frac{d \ln p}{d T} = \frac{L}{R T^2},$$

which is the familiar expression for the vapor pressure curve.

A complete expression for the vapor pressure in the case of liquids to which equation (36) applies, if the vapor approximates a perfect gas, may be derived as follows:

$$\ln \frac{v}{v' - b'} = \frac{L}{R T}.$$

Substitute $\frac{R T}{p}$ for v, and

$$\ln \frac{R T}{p (v' - b')} = \frac{L}{R T}, \quad \text{or} \quad \frac{R T}{p (v' - b')} = e^{\left(\frac{L}{R T}\right)},$$

whence $$p = \frac{R T}{(v' - b') \, e^{\left(\frac{L}{R T}\right)}}$$

III. Dimolecular Systems.

Solutions. — The simplest case of a system composed of two molecular species is one in which the two species are chemically neutral, only acting on each other by the process of solution.

Before taking up such systems it will be convenient to consider briefly, in the light of the results of the last section, a question concerning the general equation of equilibrium, namely, the nature of the function H. In equation (5), which expresses the free energy of a simple constituent of a system, the quantity $\mathfrak{H}_1$ entered as an integration constant, and nothing was known regarding its nature except that it must be independent of the temperature. After differentiating equation (5), it was found that $\frac{d\,\mathfrak{H}_1}{d\,v_1}$ was a function which could represent in the later equations the volume correction corresponding to the quantity b in the equation of van der Waals. Since this was true in the widely differing states of gas and liquid, it is probable that in any state in which the molecule itself is not changed $\frac{d\,\mathfrak{H}_1}{d\,v_1}$ may be expressed as such a volume correction, representing the diminution of the space available for the free motion of the molecules, due to the space actually occupied by the molecules themselves. If, therefore, we subtract from $\mathfrak{H}_1$ the term representing the volume correction, there will remain a quantity which will be constant under all conditions when the molecule itself does not change, and whose value will depend only on the nature of the substance considered. We will use $\mathfrak{h}$ hereafter to denote this quantity. The volume correction enters in the most general way in the consideration of a phase containing a number of molecular species. When we consider each species, the volume must be corrected for the volume actually occupied by its own molecules and also for that occupied by the other molecules present. The volume with the first correction may be expressed as in the van der Waals equation by $v - b$, where b is the correction due to the space occupied by its own molecules. The volume may be corrected for the space occupied by the other kinds of molecules by multiplying the actual volume by a factor, r, representing the fraction of any volume of the mixture which is left available for the free motion of the molecules of the particular species under consideration. The nature of this species should have no effect on the quantity r. We have, therefore, for the corrected volume of a substance dissolved in any mixture the value $r\,(v - b)$, where r depends solely on the nature of the solvent, b on that of the solute.

In taking up the subject of solutions it will be necessary to consider their probable nature. Although there is some evidence that the phenomenon of solution is accompanied by a molecular change, the preponderance of evidence seems to be in favor of the theory that the molecule of a substance in solution is free, and not combined in any chemical way with the molecules of the solvent. If this is the case, certain properties of the solute should remain unchanged regardless of the nature of the solvent. In the following work we will assume that, for a dissolved substance, the quantity $\mathfrak{h}$ as defined above and the quantity c_v will be the same in any solvent. If this supposition, which seems eminently probable, proves to be not entirely correct, then the equations developed below will only be approximations to the truth. It is to be hoped that in any case their application will conversely give us information concerning the nature of solution.

Osmotic Pressure. — The simplest phenomenon of a homogeneous solution is that of osmotic pressure, which may be determined in the following way. The change of free energy on addition of an infinitesimal amount of solvent to a solution containing one gram-molecule of solute is equal to the sum of the changes of free energy in the two constituents of the system. From equation (5), if $\frac{d\,c_v}{d\,v} = 0$, and $\frac{d\,\mathfrak{H}}{d\,v}$ becomes the volume correction, which, as is shown by Nernst,* is for each constituent, in the case of osmotic pressure, only the correction for the space occupied by the molecules of the constituent in question,

$$d\,A = \frac{R\,T}{v_1 - b_1}\,d v_1 - d\,\mathfrak{W}_1 + \frac{n\,R\,T}{v_2 - b_2}\,d v_2 - d\,\mathfrak{W}_2,$$

where the subscript 1 refers to the solute, subscript 2 to the solvent. $d v_1$, the change in molecular volume of the solute, is also the change in volume of the system, and $d\,A = p\,d\,v_1$, where p is the osmotic pressure. Therefore

$$p = \frac{R\,T}{v_1 - b_1} - \frac{d\,\mathfrak{W}}{d\,v_1} + \frac{n\,R\,T}{v_2 - b_2}\,\frac{d\,v_2}{d\,v_1}, \tag{41}$$

where $\frac{d\,\mathfrak{W}}{d\,v_1}$ represents the heat produced by the addition of $d\,v_1$ of the solvent. Except in cases of solution of such great concentration that the molecular volume of the solute and that of the solvent are not greatly different, $\frac{dv_2}{dv_1}$ is entirely negligible, and the equation for osmotic pressure becomes

* Theor. Chem., p. 209. (References to this book are to the first edition.)

$$p = \frac{R\,T}{v - b} + \frac{d\mathfrak{U}}{d\,v}. \tag{42}$$

Except that $\frac{d\mathfrak{U}}{d\,v}$ represents the heat of dilution instead of the heat of free expansion, equation (42) is identical with the equation obtained for gases. The comparison of this formula with experiment is not possible with the experimental data at present available, since, as far as I know, the heat of dilution has been determined only in the case of electrolytes, and in these cases a complication is introduced, due to the heat of dissociation. An abstract * has just come to hand of a recent work by Kistiakovski,† in which he shows that the lowering of the freezing point, which is proportional to the osmotic pressure, is, in a concentrated solution, equal to the lowering calculated for an ideal solution plus a term that is proportional to the heat of dilution. This is the result that would be given by equation (42). Kistiakovski shows that there is perfect agreement between the lowering of the freezing point calculated in this way and that found by experiment. It seems questionable, however, whether his application of the formula to electrolytes, neglecting the heat of dissociation, is justifiable. Unfortunately I have not access to his original paper.

The osmotic work obtainable from the change of a gram-molecule of a solute from a solution of one concentration to one of another concentration may be found by direct application of equation (6), or by integration of $p\,d\,v$, where p may be expressed in terms of v by means of equation (42). Then

$$A = R\,T \ln \frac{v_2 - b}{v_1 - b} + U. \tag{43}$$

For all except very concentrated solutions b may be neglected, and

$$A = R\,T \ln \frac{v_2}{v_1} + U. \tag{43a}$$

Cady ‡ has recently shown that in a galvanic cell in which the total result of the current is the passage of a certain amount of a metal from an amalgam of one concentration to one of another,

$$\pi = \frac{R\,T}{n\,e_0} \ln \frac{v_2}{v_1} + q\,,$$

* Chem. Centr. Blat., 1899, I. 89.

† Jour. Russ. Phys. Chem. Ges., XXX. 576.

‡ Jour. of Phys. Chem., II. 551, 1898.

where π is the electromotive force, v_1 and v_2 are the molecular volumes of the metal in the two amalgams, and q is the heat of the process in electrical units. From this,

$$n\,e_0\,\pi = R\,T \ln \frac{v_2}{v_1} + U,$$

but $n\,e_0\,\pi$ is the electrical work per gram-molecule, which is equal to the change of free energy, since the cell is a reversible one. Therefore $A = n\,e_0\,\pi$, or

$$A = R\,T \ln \frac{v_2}{v_1} + U,$$

which is identical with (43 a).

When we consider solutions of all concentrations, varying from the state where one of the constituents of the phase is in great excess to the state where the other constituent is in great excess, as, for example, when water is added continuously to a definite amount of alcohol, then the form which the osmotic pressure curve assumes is very complicated. Here equation (41) must be used, and $\frac{d\,v_2}{d\,v_1}$ and $\frac{d\,\mathfrak{A}}{d\,v_1}$ will both be complex functions of v_1. $\frac{d\,\mathfrak{A}}{d\,v_1}$ may be looked upon as the sum of two quantities, one due to the attraction of unlike, the other to the attraction of like molecules. Concerning the manner in which the former will change we are ignorant. The latter, however, according to reasoning exactly similar to that which led van der Waals to the term $\frac{a}{v_2}$, may be shown to be inversely proportional to the square of the volume, or equal to $\frac{a_1 + a_2}{v^2}$. We see from this that equation (41) is at least of the third degree in v_1. Bredig * and Noyes † have each proposed a general formula for osmotic pressure based upon kinetic reasoning. Both these equations are of the third degree in v. The osmotic pressure curve represented by equation (41) is not necessarily, therefore, single valued. There may be more than one volume corresponding to one osmotic pressure. This is a further analogy between solutions and gases. In fact, a number of cases are known in which the osmotic pressure may be shown to be the same at two different concentrations, namely, the cases of liquids that are mutually soluble to a limited extent, thus forming two phases in equilibrium with each other. It is evident that in order to

* Zeit. Phys. Chem., IV. 444.

† Zeit. Phys. Chem., V. 58.

preserve the equilibrium the osmotic pressure, not only of one but of each of the constituents, must be the same in the two phases. No similar phenomena have ever been observed in the case of solids dissolved in liquids, but it seems not impossible that such may be found. Then a solid might have two different solubilities in a solvent at one temperature, corresponding to two concentrations in which the osmotic pressure would be equal to the solution pressure.

Distribution of a Solute between two Solvents. — The equation of equilibrium when a substance is distributed between two solvents may be found directly from equation (11 a), simplified by the considerations advanced on page 27, namely,

$$P\,V = R\,T \ln \frac{r_2\,(v_2 - b)}{r_1\,(v_1 - b)} + U. \qquad (44)$$

In all cases of this sort $P\,V$ is entirely negligible, and

$$R\,T \ln \frac{r_2\,(v_2 - b)}{r_1\,(v_1 - b)} + U = 0, \qquad (45)$$

where v_2 and v_1 are the molecular volumes of the solute in the two solvents; b is the volume correction for the solute molecules; r_1 is the volume correction for the first solvent, and r_2 that for the second. U is the heat given off when one gram-molecule of the solute passes from one solvent to the other. It equals the difference between the heats of solution of the solute in the two solvents. In all ordinary solutions b is negligible, and the equation becomes

$$R\,T \ln \frac{r_2\,v_2}{r_1\,v_1} + U = 0. \qquad (46)$$

Since this is the general equation of distribution of a substance between two solvents, it will hold true in the special case in which the solutions are in equilibrium with the solute in the solid form. If we represent by s_1 and s_2 the solubilities in gram-molecules of the solute in one litre of each of two solvents, then $s_1 = \frac{1}{v_1}$ and $s_2 = \frac{1}{v_2}$, and equation (44) may be written

$$R\,T \ln \frac{r_2\,s_1}{r_1\,s_2} + U = 0; \qquad (47)$$

or if U' is the heat of solution in the first solvent, U'' in the second,

$$R\,T \ln \frac{r_2\,s_1}{r_1\,s_2} + U' - U'' = 0,$$

or $$R\,T \ln \frac{s_1}{r_1} + U' = R\,T \ln \frac{s_2}{r_2} + U''. \tag{48}$$

This equation permits the calculation of the solubility of a substance in any solvent if the solubility in any other solvent is known and the heat of solution in each solvent, or the difference between these heats of solution, and if the ratio of the volume corrections for the two solvents is known.

The heat of solution may be found from the change of solubility with change of temperature by the well known equation

$$\frac{d \ln s}{d\,T} = \frac{U}{R\,T^2}, \tag{49}$$

which may be obtained by direct application of equation (20), since the conditions for which (20) was obtained are all fulfilled in this case, and since the molecular volume, v_0, of the solid may be considered constant.

$$K = v_0\, s\,; \quad \ln K = \ln v_0 + \ln s\,; \quad d \ln K = d \ln s.$$

Uniting equations (48) and (49),

$$R\,T \ln \frac{s_1}{r_1} + R\,T^2 \frac{d \ln s_1}{d\,T} = R\,T \ln \frac{s_2}{r_2} + R\,T^2 \frac{d \ln s_2}{d\,T},$$

or $$\ln \frac{s_1}{s_2} + T \frac{d \ln \frac{s_1}{s_2}}{d\,T} - \ln \frac{r_1}{r_2} = 0. \tag{50}$$

When the values of r are known for the various solvents, if we know the solubility of a substance in two solvents and the temperature coefficient of the solubility in one, we may find the corresponding coefficient in the other solvent. I hope soon to verify these formulæ experimentally, and to determine the values of r for some common solvents. It will be interesting to see how r compares with the value of $v - b$ found for the solvents by equation (33).

IV. Polymolecular Systems.

(*A.*) *Homogeneous Systems.*

In accordance with the considerations advanced on page 27, the general equation of equilibrium (11 a) may be put into the form

$$P\,V = R\,T \ln \frac{[r(v_2 - b_2)]^{n_2}[r(v'_2 - b'_2)]^{n_2'} \ldots}{[r\,(v_1 - b_1)]^{n_1} \ldots} - T \int_{T_0}^{T} \frac{C_{v_1} - C_{v_2}}{T}\, d\,T + h\,T + U,$$

where h is the sum of all the $\mathfrak{h}$ terms, and $(C_{v1} - C_{v2})$ and h have the same value regardless of the nature of the solvent. If the total change in the number of molecules be n, then the quantity r will occur to the power of n, and

$$P V = R T \ln r^n \frac{(v_2 - b_2)^{n_2}(v'_2 - b'_2)^{n_2'} \ldots}{(v_1 - b_1)^{n_1} \ldots} - T \int_{T_0}^{T} \frac{C_{v_1} - C_{v_2}}{T} dT + hT + U. \quad (51)$$

Only in the case of equilibrium between gases is $P V$ considerable, for other cases $P V$ may be neglected. For equilibrium in liquid phases, if we represent by k the equilibrium ratio with the volume corrections b_1, b_2 etc., and represent $h - \int_{T_0}^{T} \frac{C_{v_1} - C_{v_2}}{T} dT$ by f,

then
$$(R T \ln r^n k) + U + f T = 0, \quad (52)$$
or
$$(R T \ln k) = - R T \ln r^n - U - f T. \quad (52a)$$

We are now in a position to answer the question how equilibrium is influenced by the nature of the solvent. If we write for equilibrium in two solvents two equations of the form of $(52\,a)$,

$$(R T \ln k') = - R T \ln r'^n - U' - f T,$$
$$(R T \ln k'') = - R T \ln r''^n - U'' - f T,$$

and subtract, we obtain, since f is the same in the two solvents, according to the assumption made on page 28,

$$\ln \frac{k'}{k''} = - n \ln \frac{r'}{r''} - \left(\frac{U' - U''}{R T}\right), \quad (53)$$

and we find that the condition of equilibrium depends on the values of r and the heat of the reaction in the two solvents. Ordinarily when the solvent does not enter into the reaction, the values of $(v_1 - b_1)$, etc. may be replaced by v_1, etc., and k, the corrected equilibrium ratio, may then be replaced by K, the ordinary equilibrium ratio. If we are dealing with reactions in which the original and final number of molecules is the same, or with any case where $n \ln \frac{r'}{r''}$ is negligible, the equation becomes

$$\ln K' - \ln K'' = \frac{U'' - U'}{R T}. \quad (54)$$

In such cases the difference between the logarithms of the equilibrium ratios in any two solvents at a given temperature is equal to the difference in the heats of the reaction divided by the gas constant and by the absolute temperature. I know of no case in which the experimental

data are at present sufficiently complete to permit the testing of equation (54).

V. Application to Electro-Chemistry.

Since the electrical work of a reversible cell is equal to the change of free energy of the process taking place in the cell, the calculation of electromotive force in many cases is possible by means of the general equation (6).

The general formula for the electromotive force of a concentration cell has already been given on page 29.

Let us consider next the subject of a single potential difference between a metal and an electrolyte containing the ions of that metal. If $\mathfrak{A}_1$ be the free energy of one gram-molecule of the metal, and $\mathfrak{A}_2$ that of one gram-molecule of its ions, then the electrical work in the electrolytic solution of one gram-molecule is

$$A = \mathfrak{A}_1 - \mathfrak{A}_2.$$

Now for $\mathfrak{A}_2$ we obtain from equation (5), modified according to page 27,

$$\mathfrak{A}_2 = - R\,T \ln r\,(v_2 - b_2) - T\int_{T_0}^{T} \frac{c_{v_2}}{T} dT + \mathfrak{h}_2 T + \mathfrak{U}_2,$$

where r is the correction for the particular solvent in which the ions are dissolved, b_2 the correction for the ions themselves, which will always be negligible. c_{v_2} and $\mathfrak{h}_2$ are independent of the nature of the particular solvent. $\mathfrak{U}_2$ is the internal energy of the ions, and if we represent by $\mathfrak{U}_1$ the internal energy in the electrode, and by U the change of internal energy in electrolytic solution, $U = \mathfrak{U}_1 - \mathfrak{U}_2$, and $-\mathfrak{U}_2$ may be replaced by $U + \mathfrak{U}_1$. Then since $\mathfrak{A}_1$, $\mathfrak{U}_1$, c_{v_2}, $\mathfrak{h}_2$, are constants at constant temperature,

$$A = C + (R\,T \ln r\,v_2) + U,$$

where C is a constant including the various terms mentioned above. If we replace v_2 by $\dfrac{R\,T}{p}$, where p is the osmotic pressure of the ions, we may write

$$A = C + (R\,T \ln R\,T) - R\,T \ln \frac{p}{r} + U = c - R\,T \ln \frac{p}{r} + U.$$

If for convenience we write $c = R\,T \ln P$,

$$A = - R\,T \ln \frac{1}{r}\frac{p}{P} + U,$$

or, since $A = \nu e_0 \pi$, where ν is the valence of the ion, e_0 the electricity carried by a gram-molecule of a univalent ion, and π the electromotive force, then

$$\pi = -\frac{RT}{\nu e_0} \ln \frac{1}{r} \frac{p}{P} + \frac{U}{\nu e_0}, \tag{55}$$

in which P differs from the electrolytic solution pressure of Nernst in that it is at constant temperature the same, no matter what the solvent may be in which the ions are dissolved, while the value of the Nernst solution pressure holds good only for water solutions. r represents the particular volume correction of the solvent.

An interesting type of cell is one in which two similar electrodes are in contact with solutions of an electrolyte containing the electrode ion in two different solvents; as, for example, zinc, zinc sulphate in water, zinc sulphate in alcohol, zinc. When a current passes through this cell, the total change consists in the transfer of zinc sulphate from one solvent to another. The free energy change in a cell of this type may be found from equation (6), modified as in equation (46),

$$A = RT \ln \frac{r_2^2 v_2 v_2'}{r_1^2 v_1 v_1'} + U, \tag{56}$$

where v_1 and v_1' are the molecular volumes of the positive and negative ions respectively, in the first solvent; v_2 and v_2', in the second solvent. Now $v_1' = g v_1$, where g is a whole number or a simple fraction; also, $v_2' = g v_2$. Therefore,

$$A = RT \ln \frac{r_2^2 v_2^2}{r_1^2 v_1^2} + U = 2RT \ln \frac{r_2 v_2}{r_1 v_1} + U. \tag{57}$$

If m represents the number of gram-molecules transferred from one solvent to the other when the quantity of electricity, νe_0, passes through the cell, then

$$\nu e_0 \pi = 2mRT \ln \frac{r_2 v_2}{r_1 v_1} + mU.$$

Let $mU = q$, then

$$\pi = \frac{2m}{\nu e_0} RT \ln \frac{r_2 v_2}{r_1 v_1} + \frac{q}{\nu e_0}. \tag{58}$$

From the equation of Helmholtz,

$$\pi = \frac{d\pi}{dT} T + \frac{q}{\nu e_0}, \tag{59}$$

and comparing (58) and (59) it is evident that

$$\frac{d\pi}{dT} = \frac{2m}{\nu e_0} R \ln \frac{r_2 v_2}{r_1 v_1}. \tag{60}$$

In an investigation which I am now making on cells of the above type I have attempted a verification of these equations in the following way. Choosing two solvents in which the value of $\ln \frac{r_2}{r_1}$ may be neglected, namely, water and a mixture of alcohol and water, then if v_2 be made equal to v_1, $\frac{d\pi}{dT}$ should equal zero. Unfortunately the dissociation in alcohol-water mixtures of the salts that are available for our purpose has not hitherto been determined. If the two solutions are made up with equivalent amounts of the original salt, then the concentration of the ions in the alcohol-water solution will be less than that in the water solution on account of the greater dissociative power of water. In the following cells, made up in this way, we should expect, therefore, a small temperature coefficient, and moreover, since the electrode in contact with the water solution is found to be negative, this temperature coefficient should be negative.

The following table gives the results obtained for the cells: — (1) Zinc; zinc sulphate, tenth normal, in water and fifty per cent ethyl alcohol. (2) Zinc; zinc sulphate, tenth normal, in water and fifty per cent methyl alcohol. (3) Cadmium; cadmium sulphate, tenth normal, in water and sixty per cent ethyl alcohol. (4) Thallium; thallium sulphate, hundredth normal, in water and twenty-seven per cent ethyl alcohol. (5) Thallium; thallium sulphate, hundredth normal, in water and forty per cent methyl alcohol.

		Temp. C	π	$\frac{d\pi}{dT}$
(1)		30	.043	—.00013
		0	.047	
(2)		23	.0475	—.00002
		0	.0480	
(3)		28	.046	—.00011
		0	.049	
(4)	A	23	.0212	.00000
		0	.0212	
	B	24	.0216	—.00001
		0	.0218	
	C	30	.0242	—.00001
		0	.0246	
(5)		24	.0380	.00000
		10	.0380	

In order to determine the actual dissociation in the above cases conductivity determinations were made. I found in the case of zinc and cadmium sulphates that the degree of the dissociation could not be found from conductivity determinations on account of peculiarities which will be discussed in a later paper. It was found, however, that in the case of cadmium sulphate the dissociation is at least five or six times as great in water as in fifty per cent methyl alcohol. In the first three cases, therefore, the value of $\frac{v_2}{v_1}$ is undoubtedly great enough to account for the values of $\frac{d\pi}{dT}$ found.

On the other hand, in the case of thallium sulphate it was found possible to determine the degree of dissociation from the conductivity data. In dilute solutions the dissociation in water and in fifty per cent methyl alcohol was found to be practically the same. This is in complete agreement with the result in case (5), where the temperature coefficient was zero. In case (5), then, the only one in which all the data are available, equation (60) is thoroughly verified. I hope to publish soon more complete results on this subject.

I wish to express my deep obligation to Professor Theodore W. Richards for his encouragement and friendly criticism of this work.

Summary.

I. (*a*) A general equation for change of free energy is developed.

(*b*) From this is derived a general expression for physico-chemical equilibrium in homogeneous or heterogeneous systems, which includes as special cases the law of isothermal mass-action and the laws of constancy of distribution coefficients among several phases.

(*c*) For change of equilibrium with change of temperature a formula is derived of which the equation of van't Hoff is a specialized form.

II. (*a*) The application of the general equations to gases yields an equation of condition which with the aid of two familiar empirical observations is shown to be identical with the equation of van der Waals.

(*b*) This equation of condition is applied to liquids in detail and special cases are discussed.

(*c*) A more complete equation is proposed, recognizing the variability of specific heat with changing volume.

(*d*) From the general equation a formula is obtained for equilibrium

between a liquid and its vapor. Heats of vaporization are calculated from this formula.

(*e*) The formula is inapplicable in cases where the specific heat at constant volume differs in the liquid and gaseous state. A method of calculating these specific heats is given.

(*f*) The formula applies perfectly in the case of mercury.

(*g*) The vapor pressure curve is discussed.

III. (*a*) Application of the general equations to solutions leads to simple expressions for osmotic pressure and osmotic work in concentrated solutions.

(*b*) Equations are given for the distribution of a solute between two solvents, and for the relation between the solubility curves of a substance in different solvents.

IV. The influence of the nature of the solvent upon general homogeneous equilibrium is determined and formulas are given.

V. (*a*) The general equation for free energy is applied to electrochemistry. For the single potential difference between a metal and an electrolyte an equation is proposed which is an amplification of the equation of Nernst.

(*b*) Galvanic cells in which two solvents take part are discussed.

PUBLICATIONS

OF THE

AMERICAN ACADEMY OF ARTS AND SCIENCES.

MEMOIRS. Old Series, Vols. I.–IV.; New Series, Vols. I.–XII. 16 volumes, $10 each. Half volumes, $5 each. 25% discount to booksellers; 50% to members.

Vol. X.	Part II. *bis*	. . . . . .	$1.75
" XI.	" I.	. . . .	2.00
" XI.	" II. No. I.	. . . . . .	3.00
" XI.	" III. " II.–III.	. . .	1.00
" XI.	" IV. " IV.	. . . . . .	1.00
" XI.	" IV. " V.	. . . . . .	.75
" XI.	" V. " VI.	. . . . . .	.25
" XI.	" VI. " VII.	. . . . .	2.00
" XII.	No. I.	. . . .	1.50
" XII.	" II.	. . . .	2.00
" XII.	" III.	. . . .	6.00
" XII.	" IV.	. . . .	1.25

PROCEEDINGS. Vols. I.–XXXIV., $5 each. 25% discount to booksellers; 50% discount to members.

Complete sets of the Memoirs, 15 vols., for $112.50, to members, $60; of the Proceedings, 34 vols. for $129, to members, $68.

Proceedings of the American Academy of Arts and Sciences.

VOL. XXXV. NO. 2. — AUGUST, 1899.

SHORT STUDIES OF NORTH AMERICAN TRYXALINÆ.

BY SAMUEL H. SCUDDER.

SHORT STUDIES OF NORTH AMERICAN TRYXALINÆ.

BY SAMUEL H. SCUDDER.

Received June 6, 1899. Presented June 14, 1899.

THE review of a large series of Tryxalinæ collected on the Pacific coast in 1897 by Mr. A. P. Morse, and kindly placed unreservedly in my hands, has provoked a re-examination of the species in a number of genera scattered through the group. I have published elsewhere (Can. Ent., XXXI. 177) a review of our species of Orphulella, and here gather together other miscellaneous studies, all referring to the Tryxalinæ.

1. THE UNITED STATES SPECIES OF MERMIRIA.

A recent study of our Mermiriæ has brought to light a couple of new species of Mermiria, and some slight extension of the known range of some of the other species, so that I venture to publish the following notes and descriptions, with a new table of the species, based primarily on that published by McNeill.

Table of the United States Species of Mermiria.

a^1. Head shorter than pronotum, or, if (rarely) as long, then the greatest width of the fastigium is greater than its length beyond narrowest part of vertex; last ventral segment of male bluntly acuminate.

b^1. Fastigium less prominent and blunter, its greatest breadth being considerably greater than its length beyond narrowest part of vertex, especially in the female.

c^1. Stouter, the hind femora shorter, not reaching the tips of the tegmina in the female; disk of pronotum, in female, hardly or not more than twice as long as greatest breadth; head with a broad occipital fuscous band. *texana* Brun.

c^2. Slenderer, the hind femora longer, reaching the tips of the tegmina in the female; disk of pronotum distinctly, generally much, more than twice as long as greatest breadth; head with a narrow occipital band or none. *bivittata* Serv.

b^2. Fastigium of vertex more prominent and angulate, its greatest breadth being scarcely greater, even in the female, than its length beyond narrowest part of vertex; disk of pronotum considerably more than twice as long as greatest breadth . . . . *intertexta* sp. nov.

a^2. Head as long as pronotum; fastigium at least as long beyond narrowest part of vertex as its extreme breadth; last ventral segment of male more produced and somewhat acutely acuminate.

b^1. Head with a relatively narrow or no occipital median fuscous stripe, which never nearly equals the width of the fastigium.

c^1. Fastigium triangular, the sides converging in a nearly straight or only slightly curved line, the tip narrowly rounded . . . . . . *alacris* Scudd.

c^2. Fastigium semielliptical, the sides converging with a well rounded curve, the tip very broadly and bluntly rounded . . . . . . *neomexicana* Thom.

b^2. Head with a broad fuscous occipital stripe, almost or quite as broad as the greatest width of the fastigium.

c^1. Fastigium semielliptical and strongly rounded apically, the sides well curved . . . . *vigilans* sp. nov.

c^2. Fastigium acutely triangular, with the sides straight and the tip hardly blunt . . . . *rostrata* McNeill.

Mermiria texana Brun.

I have seen no male of this species. My specimens come from Colorado, 7000′, Morrison, and Coahuila, Mex., Palmer. It was originally described from Texas and the State of Durango, Mex. McNeill also credits it to Arizona.

Mermiria bivittata (Serv.).

I am inclined to think that Bruner's *M. maculipennis* must be regarded as at most only a variety of this species; I have seen it from Texas and Colorado only, and all are females. McNeill accepted it with doubt, and my maculate specimens, including one named by Bruner, vary in the breadth and arcuation of the fastigium to the same extent as do those undoubtedly to be referred to *bivittata*.

This is our commonest species, and is wide spread. From east of the Mississippi I have specimens from Georgia only, but numerous specimens from Nebraska, Kansas, Colorado, Utah, Arizona, New Mexico, and Texas, and some immature specimens, which may belong here, from Iowa, collected by Allen. McNeill also credits it to Virginia, Illinois, and Nevada. Morse found it common in New Mexico on bunch grass, but it was rather shy and flew freely.

Mermiria intertexta sp. nov.

In color, markings, and size this species exactly resembles the preceding; in all specimens seen, however, there is a slender mediodorsal fuscous stripe on head and pronotum. The head is distinctly shorter than the pronotum, and the fastigium in both sexes is scarcely broader

than its length beyond the narrowest part of the vertex, being triangular (♂) or subtriangular (♀), with straight (♂) or arcuate (♀) sides and blunt apex, the margins slightly ascending, and with faint or no median carina. The median carina of the pronotum is pronounced throughout, the lateral carinæ feeble, and the disk of the pronotum considerably more than twice as long as broad, especially in the male, the transverse sulci rather feebly impressed. The tegmina reach about to the tip of the abdomen and are immaculate, with the base of the median area infuscated and bordered by a submarginal costal flavous streak, as frequently in *M. bivittata*. The hind femora are slender, and reach as far back as the tegmina in both sexes. Last ventral segment of male a little more elongate and gradually acuminate than in *M. bivittata.*

Length of body, ♂, 38 mm., ♀ 56 mm.; pronotum, ♂, 6 mm., ♀, 8.5 mm.; tegmina, ♂, 27 mm., ♀, 39 mm.; hind femora, ♂, 21.5 mm., ♀, 31 mm.

2 ♂, 2 ♀. Georgia, Morrison; Eagle Pass, Tex., Schott.

Mermiria alacris Scudd.

I have seen specimens only from Georgia, Morrison; Sandford, Fla., Frazer; and Dallas, Tex., Boll.

Mermiria neomexicana (Thom.).

My specimens come only from Pueblo, Col., Aug. 30, 31; Dallas, Boll, and Bosque Co., Tex., Belfrage. McNeill says it occurs from Wyoming to New Mexico and eastward to Georgia. I suspect his Georgia reference may be due to my remarks in describing *M. alacris*, where I speak of the present species as occurring in Georgia, but I now think that was a mistake.

Mermiria vigilans sp. nov.

Dull olivaceous with purplish and flavous markings, particularly the former. The head has a broad mediodorsal purplish fuscous stripe, broadening a little in passing backward, and as broad, at least posteriorly, as the fastigium; this is separated by a narrow flavous stripe from a broad and equal light purplish postocular stripe which continues over the upper part of the lateral lobes of the pronotum; below this the genæ are olivaceous clouded with flavous, while the face is infuscated. The pronotum is dull flavo-olivaceous, the disk often with a faint purplish median stripe, and the lateral lobes narrowly margined below with

purplish, the latter color in the male often suffusing the whole; tegmina green, the median area, especially near base, more or less ferruginous; hind femora flavous, infuscated above; hind tibiæ dull red.

Fastigium distinctly longer beyond the narrowest part of the vertex than the extreme breadth, semielliptical, the sides straighter in the male than in the female, very bluntly rounded at tip, especially in the female, the margins scarcely ascending but plane, while the centre is rotundate with no sign of median carina. Disk of pronotum about twice as long as broad, the median carina sharp throughout, the lateral carinæ distinct but not elevated, the posterior margin very broadly rounded. Tegmina reaching the tip of the abdomen. Hind femora very slender, reaching the tip of the tegmina. Last ventral segment of male short but unusually acuminate.

Length of body, ♂, 36 mm., ♀, 48 mm.; pronotum, ♂, 5 mm., ♀, 7.25 mm.; tegmina, ♂, 25 mm., ♀, 36 mm.; hind femora, ♂ 20 mm., ♀, 26 mm.

2 ♂, 4 ♀. Smithville, N. C., Nov. 22.

In markings this species seems to bear a close resemblance to *M. rostrata*, which I have not seen, but differs from it as it does from *M. alacris* in the form of the fastigium. It is most closely allied structurally to *M. neomexicana*, but has a longer pronotum and a more pointed genital segment in the male, while it differs to a considerable degree in color and markings; these, however, are variable in both species.

Mermiria rostrata McNeill.

This species, known only from Indian Territory, I have not seen.

2. Acentetus and its Species.

This genus was founded by McNeill (Proc. Dav. Acad. Nat. Sc., VI. 225) on *Acentetus unicolor*, a species described by him in the same paper from a single male without antennæ, taken in Colorado. I have a single male of the same species, taken by me at Lakin, Kansas, on Sept. 1, which agrees with McNeill's figures and description except that the whole upper surface of the head and pronotum is blackish fuscous, the genæ are narrowly striped with pale flavous or luteous and pale fuscous, and the lateral lobes have similar luteous stripes on a pale fuscous ground; the contrast of the dark disk and lighter lateral lobes does not well suit the name *unicolor*. The antennæ, the description of which had of course to be omitted from the generic characters, are depressed subfiliform, not

tapering, and distinctly longer than head and pronotum together. The scapular area of the tegmina, as represented in McNeill's figure, is too narrow; at its widest, opposite the nexus of veins in the median area, it is nearly one third the total width of the tegmina at this point.

I have a second species of Acentetus, also represented by a single male and also without antennæ, taken by me at Florissant, Col., Aug. 17–22. It is testaceous, marked with griseous and fuscous; the head is testaceous, with a pair of narrow, arcuate, diverging, fuscous occipital stripes, and on each side a pair of similar but straight postocular stripes; the disk of the pronotum is griseous and the lateral lobes testaceous below, passing rather rapidly into blackish fuscous above; the hind femora are testaceous, more or less infuscated but not at all banded, and rufous beneath, the hind tibiæ dull red. Length of body, 16.5 mm.; tegmina, 10.5 mm.; hind femora, 10.5 mm.

It differs from *A. unicolor* not only in color and markings, but also in several structural peculiarities: The median carina of the fastigium is less pronounced and indeed rather feeble; the lateral carinæ of the pronotum, though having much the same divergence, are continuous and equal throughout, thus requiring a modification of the generic definition as given by McNeill; the metazona is much more coarsely and deeply punctate; and the tegmina (in the male of course) have a very different form, the costa being very strongly arched in the distal half and the distal portion of the tegmina being much abbreviated, so that the tegmina as a whole are less than three times longer than broad, instead of five times as long as broad, as in *A. unicolor;* the relative breadth of the scapular area is even greater than in that species. It may be called *Acentetus carinatus.*

3. A Second Species of Opeia.

Opeia was founded by McNeill in 1897 (Proc. Dav. Acad. Nat. Sc., VI. 214) upon a single species, *Oxycoryphus obscurus* Thom. I have seen numerous specimens of this species coming from the Yellowstone valley in Montana, Nebraska, Lakin, Kans., Sept. 1 (Scudder), Colorado, 5500′, 7000′ (Morrison), Ft. Collins, Col., Aug. 12, 25, "on *Bouteloua oligostachya*" (Baker), Garden of the Gods, Col. (Scudder), Silver City, N. Mex. (Bruner), and Bosque Co., Tex., "on prairies" (Belfrage), as well as from Ft. Whipple, Arizona (Palmer). According to McNeill it is "a species peculiar to the Great Plains."

In 1897, Mr. A. P. Morse brought a second species from California.

— Lancaster, Aug. 1, Kern City, Aug. 4, Tulare, Aug. 5, and Lathrop, Aug. 17 (25 ♂, 17 ♀), which may be called *Opeia testacea.*

It is a slenderer insect with longer tegmina, which equal (♀) or surpass (♂) the abdomen and reach the base of the geniculation of the hind femora, and with a paler, nearly uniform coloring with scarcely any green in it, and immaculate tegmina in the female, where at most they merely have an obscure unbroken fuscous streak in the proximal half of the median area, while in *O. obscura* the female tegmina have the median area nearly always distinctly marked with fuscous, broken into quadrangular spots; in the latter species the upper half of the lateral lobes is generally marked with a broad or narrow fuscous (rarely greenish) stripe, in both sexes, extending in extreme cases upon the head as a postocular band; this is extremely rare in *O. testacea* and obscure at best, though the lateral lobes are occasionally infuscated as a whole; generally the whole pronotum is uniform pale testaceous; the hind tibial spurs are more slender in the new species, and the face a little more oblique in both sexes. Measurements of average specimens are as follows. Length of body, ♂, 14 mm., ♀, 25.5 mm.; antennæ, ♂, 5.75, ♀, 8.9 mm.; tegmina, ♂, 9.5 mm,, ♀, 15.5 mm.; hind femora, ♂, 9.4 mm., ♀, 15.6 mm.

Other species occur in Northern Mexico, which appear to be undescribed.

4. A New Genus of Orphulæ.

Among the Orthoptera brought by Mr. Morse from the Pacific coast is a new form of Orphulæ nearly allied to Chloealtis. Our genera of Orphulæ may be thus separated.

Table of the United States Genera of Orphulæ.

a^1. Antennæ relatively short, at most but little longer than head and pronotum together; scapular area of tegmina not specially dilated.

b^1. Foveolæ of vertex more or less evident; prozona not much longer than metazona; lateral lobes of pronotum transverse, that is, deeper than long; upper ulnar vein of tegmina, at least in male, apically joining the lower ulnar vein at a long distance beyond the end of the basodiscoidal field . . . *Orphulella* Stål.

b^2. Foveolæ of vertex wanting; prozona very much longer than metazona; lateral lobes of pronotum longitudinal, longer than or fully as long as deep; upper ulnar vein of tegmina, at least in male, apically strongly arched, joining the lower ulnar vein not far beyond the end of the basodiscoidal field.

c^1. Lateral lobes of pronotum plane above, meeting the disk at nearly right angles; lateral carinæ parallel throughout; tegmina usually much shorter than the abdomen in both sexes . . . . *Dichromorpha* Morse.

c^3. Lateral lobes of pronotum convex above, except for the carinæ passing rather gradually into the disk; lateral carinæ divergent on metazona; tegmina nearly or quite as long as the abdomen, at least in the male.
Clinocephalus Morse.

a^2. Antennæ long, about or more than half as long again as head and pronotum together; fastigium of vertex with a median carina; scapular area of tegmina distinctly dilated, at least in the male.

b^1. Antennæ basally depressed but not expanded, subequal to near the tip; face moderately oblique, the frontal costa subobsolete below the ocellus; lateral foveolæ of vertex obsolete; pronotum posteriorly truncate, the lateral lobes as deep as long . . . . *Chloealtis* Harr.

b^2. Antennæ basally depressed and expanded, tapering in the proximal half; face strongly oblique, the frontal costa percurrent and sulcate below the ocellus; lateral foveolæ of vertex distinct, linear; pronotum posteriorly obtusangulate, the lateral lobes longer than deep . . . . *Œonomus* gen. nov.

Œonomus (*οἰονόμος*) gen. nov.

Of slender form. Head somewhat prominent, subconical, the face strongly oblique; fastigium of vertex triangular with rounded subrectangulate apex, plane above with feebly raised blunt margins and a median carina, the lateral foveolæ distinct, linear, invisible from above; frontal costa percurrent or almost percurrent, sulcate except in the uppermost subvertical portion; eyes long-oval, oblique, not distant above; antennæ half as long again as head and pronotum together in the male, nearly as long as that in the female, the proximal half beyond the second joint depressed, expanded and tapering, in the male broader, at broadest, than the interspace between the eyes, at extreme tip again tapering slightly, at least in the male. Pronotum compressed, the disk nearly plane, faintly tectate, with parallel sides, the lateral and median carinæ similar and parallel, the front margin gently convex, the hind margin broadly obtusangulate, the lateral lobes vertical but gently rounded, longer than deep. Tegmina shorter than the body, apically subangulate, the scapular area expanded and scalariform in the male; wings aborted. Hind legs slender, the femora surpassing the abdomen, the inner spurs of hind tibiæ equal.

Œonomus altus sp. nov.

Testaceous with a lateral blackish fuscous stripe of variable width, but generally broad and deepest in color above, extending from behind the eyes across the pronotum, limited above by the lateral carinæ and continued upon the closed tegmina; otherwise devoid of markings except usually for a pair of feeble and obscure diverging fuscous stripes on the

vertex, and that the antennæ are generally much infuscated. Vertex well rounded, slightly ascending; frontal costa sparsely and irregularly punctate; eyes a little shorter, especially in the female, than the infra-ocular portion of the genæ. Pronotum with sharp and distinct carinæ, the prozona generally impunctate except anteriorly and delicately, the transverse sulci feeble, the principal sulcus angulate, especially in the female, and situated distinctly behind the middle, the metazona densely and rather finely punctate. The fuscous portion of the tegmina involves the front margin of the discoidal area, but in the male leaves the distal expanded half of the scapular area untouched, and in one female the discoidal area is sparsely punctate with fuscous; they are usually about as long as the hind femora, but in the female are sometimes no longer than head and pronotum together. Hind femora very slender, at least equalling (♀) or considerably surpassing (♂) the abdomen; hind tibiæ red, occasionally infuscated apically.

Length of body, ♂, 18 mm., ♀, 24 mm.; antennæ, ♂, 9 mm., ♀, 8.5 mm.; tegmina, ♂, 9.5 mm., ♀, 9 mm.; hind femora, ♂, 11 mm., ♀, 14.5 mm.

15 ♂, 9 ♀. Mt. Wilson, Altadena, Cal., 2400′, July 27, A. P. Morse.

5. A New Genus of Stenobothri.

The North American Stenobothri may be separated as follows: —

a^1. Antennæ not apically clavate.

b^1. Face considerably oblique, straight or little rounded; lateral foveolæ of vertex slender; lateral lobes of pronotum longer than or fully as long as deep.

c^1. Fastigium with a distinct percurrent median carina; antennæ, at least in female, depressed and more or less expanded basally.

d^1. Antennæ much expanded basally, tapering, in the male as long as the hind femora; lateral carinæ of pronotum subparallel, the disk subrectangular; prosternum tuberculate, especially in the male; tegmina shorter than the abdomen . . . . *Napaia* McNeill.

d^2. Antennæ feebly expanded basally, subfiliform, much shorter than the hind femora; lateral carinæ of pronotum strongly sinuate, the disk clepsydral; prosternum not tuberculate; tegmina longer than the abdomen. *Horesidotes* gen. nov.

c^2. Fastigium with no median carina, but at most a colored line, except sometimes in extreme anterior portion; antennæ filiform, the basal joints neither expanded nor greatly depressed in either sex; disk of pronotum clepsydral. *Stenobothrus* Fisch.

b^2. Face little oblique, strongly rounded; lateral foveolæ of vertex moderately broad, never more than twice as long as broad; lateral lobes of pronotum deeper than long.

c^1. Hind margin of pronotum more angulate than front margin; posterior margin of lateral lobes straight; tegmina and wings fully developed.

Platybothrus Scudd.

c^2. Fore and hind margins of pronotum equally (and slightly) angulate; posterior margin of lateral lobes sinuate; tegmina abbreviate and wings aborted.

Bruneria McNeill.

a^2. Antennæ apically clavate . . . . *Gomphocerus* Thunb.

Horesidotes (ὡρεσιδότης) gen. nov.

Allied to Napaia McNeill (which I have not seen) and separable from it in the points mentioned in the above table. Head subpyramidal, the face considerably oblique and straight; occiput with a median carina extending to and invading the fastigium of the vertex and throughout accompanied proximately by a pair of similar supplementary carinæ; foveolæ visible from above, elongate, shallow; eyes rather elongate; antennæ subfiliform, a little depressed but only feebly expanded basally, moderately slender, a little longer than head and pronotum together in both sexes but especially in the male, and much shorter than the hind femora. Pronotum rather small, the disk markedly clepsydral, the lateral carinæ being strongly arcuate and as distinct as the median carina; prozona and metazona of subequal length, the hind margin rounded obtusangulate; lateral lobes slightly longer than deep; prosternum not tuberculate. Tegmina extending beyond the abdomen, without intercalary vein, the apical portion of the scapular field expanded in the male. Inner calcaria of hind tibiæ subequal.

Horesidotes cinereus sp. nov.

Varying greatly from light testaceous with a slight olivaceous tinge and very feeble markings to dark cinereous with heavy markings, which in some females includes a broad median testaceous stripe on head and pronotum, bordered on the latter by a velvety black stripe cut by the luteous lateral carinæ; but in others these markings are wholly wanting, the disk and tegmina are dark cinereous flecked with griseous, and the lateral lobes are marked with a broad postocular blackish fuscous stripe extending to the eyes and separated sharply and angularly from the clay-yellow of the lower portion of the lobes. Similar differences occur in the males, and there are also some of each sex in which all markings are but faintly indicated. The antennæ are light castaneous, the wings are feebly infumate apically with black veins, and the hind femora are of the color of the upper surface, but where this is light, the upper outer carina is often marked with black; hind tibiæ glauco-luteous.

Length of body, ♂, 14.5 mm., ♀, 24.5 mm.; antennæ, ♂, 6.25 mm., ♀, 8.75 mm.; tegmina, ♂, 12 mm., ♀, 19 mm.; hind femora, ♂, 10 mm., ♀, 15.5 mm.

19 ♂, 11 ♀. Palm Springs, Cal., July 13, A. P. Morse. It occurred on grasses in dry places in Palm Cañon and West Cañon.

6. The American Species of Stenobothrus.

I have numerous specimens of Stenobothrus from west of the Mississippi and east of the Sierra Nevadas, including Dallas Co., Iowa (Allen), Nebraska (Dodge), Colorado, 5500′ and 8000′ (Morrison). Ft. Collins, Col. (Baker), Morris Ranch, Larimer Co., Col., 8500′ (Baker), Garland Col., Aug. 28–29 (Scudder), Salt Lake Valley, Utah, Aug. 1–4 (Scudder), Spring Lake Villa, Utah Co., Utah (Palmer), and Yellowstone Park, Sept. 6–12 (Scudder). These agree perfectly with eastern examples, and do not have in any case all of the characters on which McNeill separates *S. coloradensis*, on the basis of a single female specimen from Ft. Collins, Col. All the points on which he separates this species vary to a certain extent, except perhaps the length of the antennæ (in which he may have been mistaken if the antennæ were curled), and I am therefore inclined to think that *S. coloradensis* must be placed as a synonym of *S. curtipennis.* My Yellowstone Park specimens, all males, are of a smaller size than is usual; while specimens collected by R. Thaxter in sphagnum bogs at Salmonier, Newfoundland, Aug. 1–15, are unusually green and have a very peculiar aspect, but I have not discovered any good specific distinction from *S. curtipennis.*

On the other hand, Mr. A. P. Morse brought home from Oregon (Corvallis, Cordley, Portland, Sept. 18, Divide-Cottage Grove, Sept. 12, Drain, Sept. 11, Roseburg, Sept. 10, Glendale, Sept. 9, Grant's Pass, Sept. 8, and Ashland, Sept. 7), and California (Gazelle, Sept. 5, Sisson, Aug. 29, Baden, Aug. 24, Berkeley, Aug. 21, and San Francisco, Aug. 19), numerous specimens of a closely allied but more heavily marked species, which seems to be distinct and may bear the name *Stenobothrus oregonensis.* As compared with *S. curtipennis* the antennæ of the male are shorter than, instead of as long as, the hind femora, the middle joints narrower than the narrowest part of the frontal costa, instead of being at least as broad as it; the fastigium of the vertex has a distinct median carina in the anterior portion wanting or hardly discernible in *S. curtipennis ;* the disk of the metazona is marked distinctly and generally broadly at the sides with black, instead of being generally immaculate or narrowly mar-

gined with black laterally; the male tegmina are shorter, generally much shorter than the abdomen, with rare exceptions as long as the abdomen; instead of being at least as long as, in macropterous forms considerably longer than the abdomen, the vena plicata joining the vena dividens before the middle or fading at some distance before the middle, instead of running free past the middle of the tegmina. In general it is more heavily marked, has shorter tegmina and slenderer antennæ. In the female the tegmina are but little longer than the head and pronotum together, sometimes no longer. It should at least be distinguished as a race; future collections in the intermediate regions will probably show more clearly whether it should be regarded as wholly distinct.

7. Psoloessa and Stirapleura.

In his Revision of the North American Tryxalinæ (Proc. Dav. Acad. Sc., VI.), McNeill placed these two genera side by side at the end of his series. Later, in my Preliminary Classification of the same subfamily (Psyche, VIII.), I placed them at some distance apart, Psoloessa among the Phlibostromæ and Stirapleura in the Scyllinæ. This change of mine was wrong and came from incorrect observation of the foveolæ of the vertex (a distinction on which I placed a wider reliance than McNeill), for in Psoloessa they are partially visible from above, their plane being twisted feebly in relation to that of the margin of the vertex, so that while they are visible from above on their inner half, they are not so on their outer half. The other features of Psoloessa show that it belongs to the Scyllinæ, and I would restore it to the immediate vicinity of Stirapleura, to which it is very closely allied.

The table given by me for the separation of the genera of Scyllinæ may be altered by substituting the following for the final paragraph relating to Stirapleura (Psyche, VIII. 231): —

Pronotum constricted in the middle, the prozona slightly the shorter; lateral carinæ percurrent, more or less divergent in front and strongly divergent behind.

Foveolæ of vertex visible from above only on the inner half; lateral carinæ of pronotum anteriorly but little or at least not strongly divergent, being gently arcuate on the prozona; lateral lobes of prozona feebly or not marked above the middle with obliquely disposed short lunate carinules . . . *Psoloessa* Scudd.

Foveolæ of vertex visible from above throughout their length; lateral carinæ of pronotum very strongly divergent in front as well as behind, being strongly bent-arcuate on the prozona; lateral lobes of prozona more or less conspicuously rugose-carinate obliquely above the middle . . . . . . *Stirapleura* Scudd.

This definition will leave *P. texana* Scudd. in Psoloessa, instead of transferring it to Stirapleura, as was done by McNeill, doubtless on account of the slightly more marked oblique carinæ of the lateral lobes of the pronotum. The face is generally a little more oblique in Psoloessa than in Stirapleura, but the distinctions drawn by McNeill from the frontal costa hold in Psoloessa only for *P. buddiana* Brun.

As to the species of Stirapleura, I am inclined to look on the form from southern California, heretofore regarded as identical with *S. delicatula* (Scudd.) of Colorado to be distinct from though closely allied to it. I have before me a considerable series (more than a hundred) of each, and I find the Californian species to have a slenderer form, longer tegmina and wings, and the upper inner angle of the lateral foveolæ of the vertex distinctly more rounded so as to make them less distinctly rhomboidal than in *S. delicatula*. I describe it herewith, together with another new species from Texas, remarkable for the delicacy of the lateral carinæ of the pronotum and approaching Psoloessa in the feebleness of the oblique carinæ of the lateral lobes.

Stirapleura pusilla sp. nov.

Head moderately prominent, subascending, the fastigium of the vertex rather deeply sulcate with elevated, anteriorly acutangulate margins; lateral foveolæ nearly or quite half as long again as greatest breadth, subrhomboidal, but narrower interiorly than exteriorly, with the inner upper angle distinctly rounded; frontal costa much contracted at summit, more or less gradually broadening, sulcate throughout but only feebly at base, punctate within the raised and smooth margins; antennæ distinctly but not greatly longer than head and pronotum together, especially in the male. Pronotum considerably constricted mesially, the posterior margin obtusangulate, the median carina moderately prominent, equal, cut barely in advance of the middle, the lateral carinæ equally prominent, bent-arcuate and strongly divergent, especially behind, so that the disk of the pronotum is about twice as broad posteriorly as near the middle, the lateral lobes more or less corrugated at the shoulder just below the lateral carinæ. Color cinereous, generally much marked with fuscous and black, paler beneath than above, but very variable; face generally testaceous, the frontal costa more or less infuscated, the genæ generally dotted with fuscous or infuscated, sometimes with the exception of a broad arcuate oblique subocular stripe; the occiput may or may not be striped with testaceous and fuscous, but there is usually a broad postocular fuscous stripe extending across the lateral lobes, where it is often followed below

by a testaceous stripe, below which the lateral lobes are again infuscated, but often enlivened below the middle posteriorly by a more or less conspicuous oblique flavo-testaceous bar, sometimes merged in the lighter color of the lowest portion; disk of pronotum testaceous more or less infuscated, the carinæ usually flavous and the metazona with a triangular black patch on either side. Tegmina surpassing the hind femora in both sexes, more or less heavily flecked with fuscous, ranging from a nearly uniform sprinkling throughout with fuscous dots to a regular series of six or more quadrate fuscous blocks in the median area; wings hyaline with black veins. Hind femora considerably surpassing the abdomen, cinereous or cinereo-testaceous, generally marked above with a median triangular black-edged brown spot and often also with less conspicuous basal and postmedian fuscous patches, the geniculation more or less infuscated; hind tibiæ pallid with a glaucous tinge and generally flecked more or less conspicuously with fuscous, the base with a postgenicular infumated annulus, the spines black-tipped.

Length of body, ♂, 10.5 mm., ♀, 18 mm.; antennæ, ♂, 5.2 mm., ♀, 6.5 mm.; tegmina, ♂, 10.5 mm., ♀, 15 mm.; hind femora, ♂, 8.5 mm., ♀, 12.75 mm.

89 ♂, 80 ♀. Mesilla, N. Mex., July 1 (Morse); and the following from California: San Diego, July 22 (Morse); Coronado, July 24 (Morse); San Bernardino, July 16 (Morse); Cahon Pass, July 18 (Morse); Los Angeles, July 21 (Morse), Oct. 24 (Scudder); Altadena, July 29, and Mt. Wilson, 2400′, July 27 (Morse); Pasadena, Oct. 23 (Scudder); Santa Barbara, Oct. 21 (Scudder); Lancaster, July 31, Aug. 1 (Morse); Tehachapi, Aug. 2 (Morse); Kern City, Aug. 4 (Morse); Tulare, Aug. 5 (Morse); Monterey, Oct. 18 (Scudder); Raymond, Aug. 16 (Morse), and Ahwanee, Aug. 15 (Morse).

At Mesilla, Mr. Morse found this insect common on sand and gravel on the mesa, scarce on weeds and tall grass along ditches.

Stirapleura tenuicarina sp. nov.

Head not very prominent, the fastigium of the vertex moderately narrow, deeply sulcate with elevated margins acutangulate in front; lateral foveolæ almost exactly quadrate, barely longer than broad, distinctly impressed; frontal costa pinched above, gradually enlarging throughout and sulcate, though scarcely so at base and directly above the ocellus, very sparsely punctate; antennæ a little shorter than head and pronotum together. Pronotum not greatly constricted mesially, the posterior margin broadly obtusangulate, a little rounded, the median

carina only slightly prominent, equal, cut distinctly in advance of the middle, the lateral carinæ delicate, feebly elevated, briefly parallel just in front of the middle, but widely divergent in advance, as behind; lateral lobes with subdued corrugations at the shoulder just below the lateral carinæ. Color fusco-cinereous, the head testaceous with pallid genæ, plumbeo-fuscous above; antennæ testaceous interrupted with fuscous; pronotum nearly uniform obscure fusco-testaceous, the carinæ concolorous; tegmina cinereous much flecked with fuscous especially in quadrate patches along the median area, one beyond the middle larger than the rest and divided by an oblique pallid bar; wings hyaline with black veins; hind femora cinereo-testaceous with a ferruginous tinge and blotched with fuscous, above rather obscurely trimaculate with fuscous; hind tibiæ pale ferrugineo-luteous, deepening in tint distally.

Length of body, 22.5 mm.; antennæ, 5.75 mm.; tegmina, 19.5 mm.; hind femora, 13.75 mm.

1 ♀. Sierra Blanca, El Paso Co., Tex., June 26, A. P. Morse.

8. The Species of Aulocara.

Aulocara Scudd. has as synonyms Œdocara Scudd. and Coloradella Brunn. (See Can. Ent., XXIX. 75, and Psyche, VII. 71.) No species have been referred to the last named, but to the others five nominal species have been referred; *elliotti* Thom., *cæruleipes* Scudd., *decens* Scudd., *strangulatum* Scudd., and *scudderi* Brun. *Scudderi*, as has been shown by McNeill, belongs to Ageneotettix (Eremnus). The other four all represent a single species, which must bear the oldest name, *elliotti*. Nevertheless we possess four species which may be separated by the following table: —

Table of the Species of Aulocara.

a^1. Fastigium of vertex broader than long, its front margin obtusangulate; metazona feebly tumescent, its hind margin not very broadly obtusangulate; hind tibiæ red . . . . *rufum* sp. nov.

a^2. Fastigium of vertex at least as long as broad, its front margin rectangulate or acutangulate; metazona plane or nearly plane, its hind margin broadly obtusangulate; hind tibiæ purple,* or glaucous.

b^1. Pronotum strongly constricted mesially, the disk with more or less conspicuously decussate markings, the lateral carinæ strongly divergent in front and behind.

c^1. Male antennæ as long as thorax and abdomen combined; lower margin of lateral foveolæ of vertex obsolete or obsolescent; tegmina generally immaculate, much shorter than the long hind femora . . . . . *femoratum* sp. nov.

* The hind tibiæ of *A. parallelum* are not known, but are presumably purple.

c^2. Male antennæ shorter than thorax and abdomen combined; lower margin of lateral foveolæ of vertex distinct; tegmina generally maculate, generally fully as long as the relatively shorter hind femora . . . . . *elliotti* Thom.

b^2. Pronotum but feebly constricted mesially, the disk of subequal width and unicolorous, the lateral carinæ divergent only, and but little, behind.

parallelum sp. nov.

Aulocara rufum sp. nov.

Head well rounded, rather large, ferrugineo-cinereous, paler on face, with a pair of obscure fuscous stripes on summit and more or less flecked with fuscous or ferruginous on upper part of genæ; summit tumid, the fastigium much broader than long, with slightly raised, parallel lateral margins, the front margin distinctly obtusangulate; lateral foveolæ obsolescent, scarcely impressed, subtriangular, longer than broad; frontal costa of moderate breadth, subequal but feebly narrowed above, obsolescent below with slightly and narrowly elevated margins; antennæ ferruginous, more or less infuscated, in the male as long as the hind femora. Pronotum nearly uniform rufous, more or less infuscated on disk, especially on metazona, not greatly constricted mesially, the metazona feebly tumescent, the hind margin a little obtusangulate, the angle sometimes much rounded, the median carina slight and confined to the metazona. Tegmina broad and well rounded, rufous, minutely sprinkled with fuscous, hardly surpassing the hind femora; wings hyaline, the veins glaucous, sometimes infuscated. Hind femora cinereo-testaceous, often more or less ferruginous, generally very obscurely (but occasionally in male distinctly) bifasciate with fuscous; hind tibiæ light red, pallescent basally.

Length of body, ♂, 14 mm., ♀, 19 mm.; antennæ, ♂, 8 mm., ♀, 8.75 mm.; tegmina, ♂, 11.5 mm., ♀, 15.5 mm.; hind femora, ♂, 8 mm., ♀, 12 mm.

5 ♂, 4 ♀. Pueblo, Col., July 8–9, Aug. 30–31.

This species is very distinct from all the others, not only in the coloring of the body, tegmina, and hind tibiæ, but in the breadth of the fastigium of the vertex, the obscurity of the foveolæ, the absence of a median carina on the prozona, and the lesser obtuseness of the hind margin of the metazona.

Aulocara femoratum sp. nov.

Of minor size, the head well rounded and rather prominent, cinereo-testaceous, a little infuscated above; summit tumid, the fastigium deeply excavate, considerably longer than broad, the margins rather sharply elevated, the lateral parallel, the front acutangulate; lateral foveolæ triangular, of moderate size, distinctly impressed, but with obsolescent or no

inferior margin ; frontal costa rather narrow, subequal but slightly compressed above, obsolete below, more or less but generally feebly sulcate; antennæ testaceous, infuscated except near base, of unusual length though not quite so long as the long hind femora. Pronotum testaceous, the disk somewhat infuscated, considerably constricted mesially, the lateral lobes with a large and distinct, quadrate, subcentral but superior, fuscous patch, the metazona plane, the hind margin subtruncate but feebly angulate, the median carina distinct, equal, percurrent, the lateral carinæ blunt and obscure except where marked with pale testaceous, strongly divergent in front and behind. Tegmina short and well rounded, when closed not nearly covering the abdomen, testaceous, sometimes feebly infuscated or minutely and obscurely flecked with fuscous; wings hyaline with glaucous veins. Hind femora of unusual length, much surpassing the abdomen, testaceous, obliquely biannulate with blackish fuscous, the geniculation broadly black; hind tibiæ glaucous, basally pallescent.

Length of body, 15 mm.; antennæ, 9.5 mm.; tegmina, 7.5 mm. ; hind femora, 10.75 mm.

5 ♂. Lakin, Kans., Sept. 1 ; Colorado, 5500′, Morrison; Pueblo, Col., Aug. 30–31 ; Provo, Utah, Aug. 23-24.

I have based this species upon the male specimens just quoted, but I have also three females from Lakin and Pueblo, with short wings and long hind femora, which I think belong here, but which resemble *A. elliotti* more than do the males. The species is smaller than any of its congeners, with shorter wings, longer hind femora, and subtruncate posterior margin of the pronotum.

Aulocara elliotti.

Stauronotus elliotti Thom., Proc. Acad. Nat. Sc., Philad., 1870, 82 (1870).
Œdocara elliotti Sauss., Prodr. Œdip., 79 (1884).
Aulocara elliotti Brun., Can. Ent., XVII. 10 (1885).
Aulocara cœruleipes Scudd. !, Bull. Hayd. Surv., II. 266 (1876).
Aulocara decens Scudd. !, Ibid., II. 267 (1876).
Œdocara strangulatum Scudd. !, Ann. Rep. Wheel. Surv., 1876, 289 (1876).

I have specimens, mostly collected by myself, from Kansas (Lakin, Sept. 1); Colorado (southern Colorado, June 11–20, Carpenter; Animas, July 8–9; Granada, July 8–9; Pueblo, July 8–9; Garden of the Gods, July 13, Packard; Florissant, Aug. 17–22); Texas (Fort Worth, July 4); New Mexico (Johnson's Basin, June 22, Townsend); Arizona (Fort Whipple, Palmer); Utah (Castle Gate, Aug. 22; Lake Point, Salt Lake, July 26, Packard; Salt Lake valley, Aug. 1–4); and Cali-

fornia (Tehachapi, Aug. 2, A. P. Morse, the last of an unusually large size); also mountains 12 leagues east of San Luis, Mexico, E. Palmer.

It has also been credited to Nebraska (Bruner), Wyoming (Thomas), the Yellowstone region (Bruner), Montana (Thomas), and Washington (Bruner).

The species varies much in coloring, from nearly immaculate to markedly maculate, and also in the length of the tegmina, which, though rarely as short as the hind femora, may sometimes far surpass them in length.

Aulocara parallelum sp. nov.

Head well rounded, rather large and prominent, cinereo-testaceous, feebly infuscated above, and with a broad and broadening postocular, blackish fuscous stripe, extending over the prozona; summit tumid, the fastigium depressed, with well elevated margins, rather longer than broad, at least in the male, the lateral margins parallel, the front acutangulate, particularly in the male; lateral foveolæ triangular, elongate, tolerably well impressed, with coarse raised margins; frontal costa not very broad, in the male much constricted above and gradually broadening, percurrent and rather deeply sulcate, in the female subequal, obsolete below, faintly sulcate at and below the ocellus. Pronotum dull testaceous, with the postocular stripe mentioned, very broad in front and rapidly narrowing, sometimes extended over the metazona on the upper margin of the lateral lobes, feebly constricted mesially, the metazona plane, the hind margin very broadly obtusangulate, the median carina distinct and percurrent, but feeble or obsolete between the sulci, the lateral carinæ diverging, and not greatly, only behind, so that the disk is subequal in width. Tegmina extending to tip of abdomen, well rounded, testaceous, more or less infuscated along the median area and especially in the proximal half; wings hyaline, the veins glaucous except apically in anterior area where they are fuscous. Hind legs lost in only specimens seen.

Length of body, ♂, 19 mm., ♀, 28 mm.; tegmina, ♂, 13.5 mm., ♀, 20 mm.

1 ♂, 1 ♀. Salt Lake Valley, Utah, Aug. 1–4.

This species is remarkable for the parallelism of the lateral carinæ on the prozona, giving a disk of subequal width, and for the lack of decussate markings, combined with the presence of a broad postocular stripe.

PUBLICATIONS

OF THE

AMERICAN ACADEMY OF ARTS AND SCIENCES.

MEMOIRS. Old Series, Vols. I.–IV.; New Series, Vols. I.–XII. 16 volumes, \$10 each. Half volumes, \$5 each. 25% discount to booksellers; 50% to members.

Vol. X.	Part II. *bis*	\$1.75
" XI.	" I.	2.00
" XI.	" II. No. I.	3.00
" XI.	" III. " II.–III.	1.00
" XI.	" IV. " IV.	1.00
" XI.	" IV. " V.	.75
" XI.	" V. " VI.	.25
" XI.	" VI. " VII.	2.00
" XII.	No. I.	1.50
" XII.	" II.	2.00
" XII.	" III.	6.00
" XII.	" IV.	1.25

PROCEEDINGS. Vols. I.–XXXIV., \$5 each. 25% discount to booksellers; 50% discount to members.

Complete sets of the Memoirs, 15 vols., for \$112.50, to members, \$60; of the Proceedings, 34 vols. for \$129, to members, \$68.

Proceedings of the American Academy of Arts and Sciences.

VOL. XXXV. NO. 5. — OCTOBER, 1899.

TWO GENERA OF NORTH AMERICAN DECTICINÆ.

BY SAMUEL H. SCUDDER.

THE ECHELON SPECTROSCOPE.

By A. A. Michelson.

Received and Presented October 11, 1899.

The important discovery of Zeeman of the influence of a magnetic field upon the radiations of an approximately homogeneous source shows more clearly than any other fact the great advantage of the highest attainable dispersion and resolving power in the spectroscopes employed in such observations.

If we consider that in the great majority of cases the separation of the component lines produced by the magnetic field is of the order of a twentieth to a fiftieth of the distance between the sodium lines, it will be readily admitted that, if the structure of the components themselves is more or less complex, such structure would not be revealed by the most powerful spectroscopes of the ordinary type.

In the case of the grating spectroscope, besides the difficulty of obtaining sufficient resolving power, the intensity is so feeble that only the brighter spectral lines can be observed, and even these must be augmented by using powerful discharges, — which usually have the effect of masking the structure to be investigated.

Some years ago I published a paper describing a method of analysis of approximately homogeneous radiations which depends upon the observation of the clearness of interference fringes produced by these radiations. A curve was drawn showing the change in clearness with increase in the difference of path of the two interfering pencils of light; and it was shown that there is a fixed relation between such a "visibility curve" and the distribution of light in the corresponding spectrum, — at least in the case of symmetrical lines.*

It is precisely in the examinations of such minute variations as are observed in the Zeeman effect that the advantages of this method appear, for the observations are entirely free from instrumental errors; there is practically no limit to the resolving power, and there is plenty of light.

* In the case of asymmetrical lines another relation is necessary, and such is furnished by what may be called the "phase curve."

There is, however, the rather serious inconvenience that the examination of a single line requires a considerable time, often several minutes, and during this time the character of the radiations themselves may be changing.

Besides this, nothing can be determined regarding the nature of these radiations until the "visibility curve" is complete, and analyzed either by calculation or by an equivalent mechanical operation.

Notwithstanding these difficulties, it was possible to obtain a number of rather interesting results, such as the doubling or the tripling of the central line of Zeeman's triplet, and the resolution of the lateral lines into multiple lines; also the resolution of the majority of the spectral lines examined into more or less complex groups; the observation of the effects of temperature and pressure on the width of the lines, etc.

It is none the less evident that the inconveniences of this process are so serious that a return to the spectroscopic methods would be desirable if it were possible, 1st, to increase the resolving power of our gratings; 2d, to concentrate all the light in one spectrum.

It is well known that the resolving power of a grating is measured by the product of the number of lines by the order of the spectrum. Attention has hitherto been confined almost exclusively to the first of these factors, and in the large six-inch grating of Professor Rowland there are about one hundred thousand lines. It is possible that the limit in this direction has already been reached; for it appears that gratings ruled on the same engine with but half as many lines have almost the same resolving power as the larger ones. This must be due to the errors in spacing of the lines; and if this error could be overcome, the resolving power could be augmented indefinitely.

In the hope of accomplishing something in this direction, together with Mr. S. W. Stratton, I constructed a ruling engine in which I make use of the principle of the interferometer in order to correct the screw by means of light-waves from a homogeneous source. This instrument (only a small model of a larger one now under construction) has already furnished rather good gratings of two inches ruled surface, and it seems not unreasonable to hope for a twelve-inch grating with almost theoretically accurate rulings.

As regards the second factor, the order of the spectrum observed, but little use is made of orders higher than the fourth, chiefly on account of the faintness of the light. It is true that occasionally a grating is ruled which gives exceptionally bright spectra of the second or third order, and such gratings are as valuable as they are rare; for it appears

that this quality of throwing an excess of light in a particular spectrum is due to the character of the ruling diamond, which cannot be determined except by the unsatisfactory process of trial and error.

If it were desired to produce rulings which should throw the greater part of the incident light in a given spectrum, we should try to give the rulings the form shown in section in Figure 1.

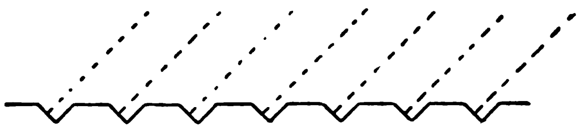

FIGURE 1.

I am aware of the difficulties to be encountered in the attempt to put this idea into practical shape, and it may well be that they are in fact insurmountable; but in any case it seems to be well worth the attempt.

Meanwhile the idea suggested itself of avoiding the difficulty in the following way.

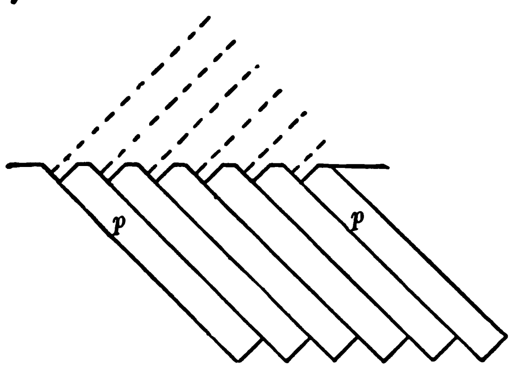

FIGURE 2.

Plates of glass (*p p*, Fig. 2) accurately plane-parallel and of the same thickness, are placed in contact, as shown in the figure. If the thicknesses were exactly the same, and were it not for variations in the thickness of the air-films between the plates, the retardations of the pencils reflected by the successive surfaces would be exactly the same, the reflected waves would be in the same conditions as in the case of a reflecting grating, — except that the common retardation is enormously greater.

The first condition is not very difficult to fulfil; but, in consequence of dust particles which invariably deposit on the glass surfaces, — in spite of the greatest possible precaution, — it is practically impossible to insure a perfect contact, or even constancy, in the distances between surfaces.*

If now instead of the retardation by reflection we make use of the retardation by transmission through the glass, the difficulty disappears almost completely. In particular the air-films are compensated by equivalent thicknesses of air outside, so that it is no longer necessary that their thickness should be constant. Besides, the accuracy of parallelism and of thickness of the glass plates necessary to insure good results is now only one fourth of that required of the reflection arrangement.

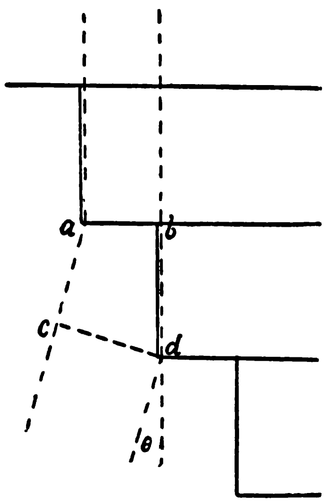

FIGURE 3.

In Figure 3 let $ab = s$, the breadth of each pencil of rays; $bd = t$, the thickness of each element of the echelon; θ, the angle of diffraction; α, the angle adb; m, the number of waves of length λ corresponding to the common difference of path of the successive elements. The difference of path is $m\lambda = \mu t - ad$. $ac = \dfrac{t}{\cos\alpha}\cos(\alpha + \theta)$; or, since θ is always very small,

$$ac = \frac{t}{\cos\alpha}(\cos\alpha - \theta\sin\alpha) = t(1 - \theta\tan\alpha),$$

and

$$m\lambda = (\mu - 1)t + s\theta. \qquad \text{I.}$$

To find the angle corresponding to a given value $d\lambda$, differentiate for λ, and we find $\dfrac{d\theta}{d\lambda} = \dfrac{1}{s}\left(m - t\dfrac{d\mu}{d\lambda}\right)$.

Putting in this expression the approximate value of $m = (\mu - 1)\dfrac{t}{\lambda}$, we have

* Nevertheless I have succeeded with ten such plates, silvered on their front surfaces, in obtaining spectra which, though somewhat confused, were still pure enough to show phenomena such as the Zeeman effect, the broadening of lines by pressure, etc.; but evidently the limit had been nearly reached.

$$\frac{d\theta}{d\lambda/\lambda} = \left[(\mu - 1) - \lambda\frac{d\mu}{d\lambda}\right]\frac{t}{s} = b\frac{t}{s}. \qquad \text{II.}$$

For the majority of optical glasses b varies between 0.5 and 1.0.

The expression II. measures the dispersion of the echelon. To obtain the resolving power, put $e = d\lambda/\lambda$ for the limit. For this limiting value the angle θ will be $\lambda/n\,s$, where n is the number of elements; hence $n\,s =$ the effective diameter of the observing telescope. Substituting these values, we find

$$e = \frac{\lambda}{b\,n\,t}. \qquad \text{III.}$$

To obtain the angular distance between the spectra, differentiate I. for m; we find

$$\frac{d\theta}{dm} = \frac{\lambda}{s}; \text{ or, putting } d\,m = \text{unity,}$$

$$d\theta_1 = \frac{\lambda}{s}. \qquad \text{IV.}$$

The quantity $d\lambda/\lambda = E$ corresponding to this is found by substituting this value of $d\theta$ in II., whence

$$E = \frac{\lambda}{b\,t}. \qquad \text{V.}$$

Hence the limit of resolution is the nth part of the distance between the spectra.

This fact is evidently a rather serious objection to this form of spectroscope. Thus, in observing the effect of increasing density on the breadth of the sodium lines, if the broadening be of the order of $\lambda/b\,t$ the two contiguous spectra (of the same line) will overlap. As a particular case, let us take $t = 7$ mm., $E = \frac{1}{14000}$. It will be impossible to examine lines whose breadth is greater than the fourteenth part of the distance between the D lines. It is evidently advantageous to make t as small as possible.

Now the resolving power, which may be defined by $\frac{1}{e}$ is proportional to the product $n\,t$. Consequently in order to increase it as much as possible it is necessary to use thick plates, or to increase their number. But in consequence of the losses by the successive reflections, experience shows that this number is limited to from 20 to 35 plates, any excess not contributing in any important degree to the efficiency.

I have constructed three echelons, the thickness of the plates being

7 mm., 18 mm., and 30 mm. respectively, each containing the maximum number of elements, — that is, 20 to 35, and whose theoretical resolving powers are therefore of the order of 210000, 540000, and 900000, respectively. In other words, they can resolve lines whose distances apart is the two-hundredth, the five-hundredth, and the nine-hundredth of the distance between the D lines.

Consequently the smallest of these echelons surpasses the resolving power of the best gratings, and what is even more important, it concentrates all the light in a single spectrum.

The law of the distribution of intensities in the successive spectra is readily deduced from the integral

$$A = \int_{s/2}^{s/2} \cos p x \, dx, \quad \text{where} \quad p = \frac{2\pi}{\lambda}\theta.$$

Hence

$$I = A^2 = \frac{\sin^2 \pi \frac{s}{\lambda}\theta}{\left(\pi \frac{s}{\lambda}\theta\right)^2}.$$

This expression vanishes for $\theta = t\lambda / s$, which is also the value of $d\theta_1$, the distance between the spectra.

Hence in general there are two spectra visible as indicated in Figure 4.

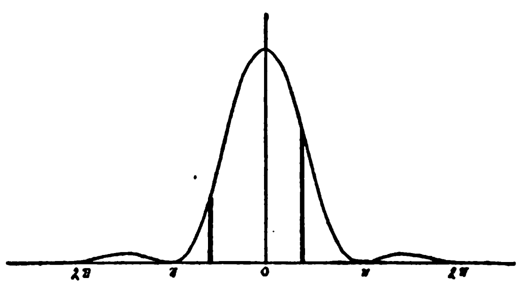

FIGURE 4.

By slightly inclining the echelon, one of the spectra is readily brought to the centre of the field, while the adjacent ones are at the minima, and disappear. The remaining spectra are practically invisible, except for very bright lines.

As has just been indicated, the proximity of the successive spectra of one and the same line is a serious objection, and as this proximity depends

on the thickness of the plates — which for mechanical reasons cannot well be reduced below 5 or 6 mm. — it is desirable to look to other means for obviating the difficulty, among which may be mentioned the use of a liquid instead of air.

In this case Formula II. becomes

$$\frac{d\theta}{d\lambda/\lambda} = \frac{t}{s}\left[\frac{1}{\mu_1}(\mu - \mu_1) - \lambda\frac{d(\mu - \mu_1)}{d\lambda}\right] = c\frac{t}{s}$$

and Formula IV. becomes

$$\frac{d\theta}{dm} = \frac{\lambda}{\mu_1 s}.$$

Repeating the same operations as in the former case, we find:

$$e = \frac{\lambda}{n c t},$$

and

$$E = \frac{\lambda}{c t}.$$

The limit of resolution is still the n'th part of the distance between the spectra, but both are increased in the ratio b/c.

Suppose for instance the liquid is water. Neglecting dispersion the factor would be 3.55. Hence the distance between the spectra will be increased in this proportion, but the limit of resolution will also be multiplied by this factor. But as there is now a surface water-glass which reflects the light, the loss due to this reflection will be very much less, so that it will be possible to employ a greater number of elements, thus restoring the resolving power. At the same time the degree of accuracy necessary in working the plates is 3.55 times less than before.

For many radiations the absorption due to thicknesses of the order of 50 cm. of glass would be a very serious objection to the employment of the transmission echelon. I have attempted, therefore, to carry out the original idea of a reflecting echelon, and it may be of interest to indicate in a general way how it is hoped the problem may be solved.

Among the various processes which have suggested themselves the following appear the most promising.

In the first a number of plates (20 to 30), of equal thickness, are fastened together as in Figure 5, and the surfaces A and B are ground and polished plane and parallel. They are then separated and placed on an inclined plane surface, as indicated in Figure 6.

If there are differences in thickness of the air-films, the resulting differences in the height of the plates will be less in the ratio tan α.

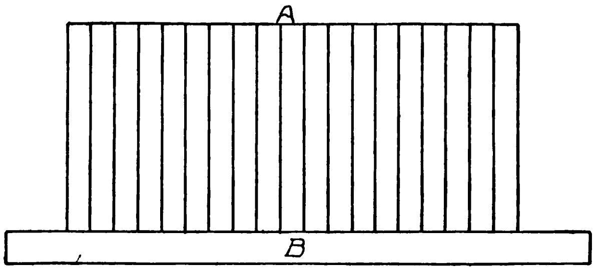

FIGURE 5.

An error of λ/n may be admitted for each plate, — even in the most unfavorable case in which the errors all add; and consequently the admissible errors in the thickness of the air-films may be of the order $\lambda/n\alpha$. For instance, for 20 plates the average error may be a whole wave-length if the inclination α is $\frac{1}{20}$. As there is always a more or

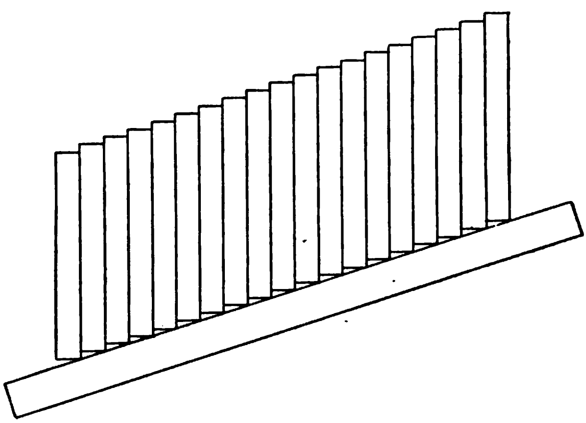

FIGURE 6.

less perfect compensation of the errors, the number of plates or the inclination may be correspondingly greater. Accordingly, it may be possible to make use of 50 elements, and the plane may be inclined at an angle of 20° to 30°. It would be necessary in this case, however, to use a rather large objective. Possibly this may be avoided by cutting the surface A to a spherical curvature, thus forming a sort of concave echelon.

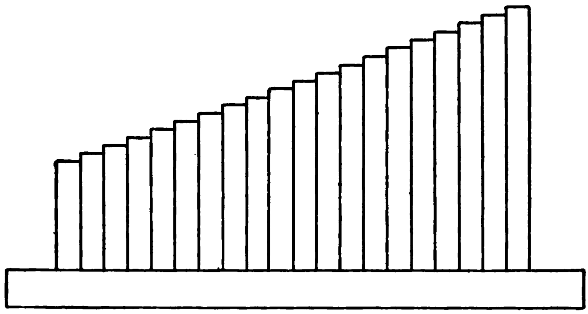

FIGURE 7.

The second process differs from the first only in that each plate is cut independently to the necessary height to give the required retardation. The first approximation being made, the plates are placed on a plane surface, as in Figure 7.

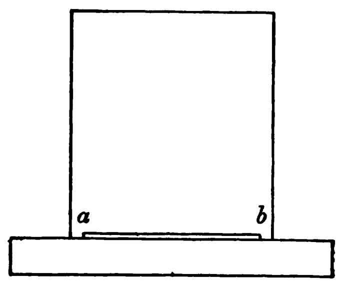

FIGURE 8.

The projections *a* and *b* (Fig. 8) are then ground and polished until the upper surfaces are all parallel, and the successive retardations equal. The parallelism as well as the height is verified by means of the interferometer.

These processes are, it is freely conceded, rather delicate, but preliminary experiments have shown that with patience they may be successful.

PUBLICATIONS

OF THE

AMERICAN ACADEMY OF ARTS AND SCIENCES.

MEMOIRS. Old Series, Vols. I.–IV.; New Series, Vols. I.–XII. 16 volumes, $10 each. Half volumes, $5 each. 25% discount to booksellers; 50% to members.

Vol. X.	Part II. *bis*	$1.75
" XI.	" I.	2.00
" XI.	" II. No. I.	3.00
" XI.	" III. " II.–III.	1.00
" XI.	" IV. " IV.	1.00
" XI.	" IV. " V.	.75
" XI.	" V. " VI.	.25
" XI.	" VI. " VII.	2.00
" XII.	No. I.	1.50
" XII.	" II.	2.00
" XII.	" III.	6.00
" XII.	" IV.	1.25

PROCEEDINGS. Vols. I.–XXXIV., $5 each. 25% discount to booksellers; 50% discount to members.

Complete sets of the Memoirs, 15 vols., for $112.50, to members, $60; of the Proceedings, 34 vols. for $129, to members, $68.

Proceedings of the American Academy of Arts and Sciences.

VOL. XXXV. NO. 8. — DECEMBER, 1899.

THE ELECTROCHEMICAL EQUIVALENTS OF COPPER AND SILVER.

BY THEODORE W. RICHARDS, EDWARD COLLINS, AND GEORGE W. HEIMROD.

CONTRIBUTIONS FROM THE CHEMICAL LABORATORY OF HARVARD COLLEGE.

THE ELECTROCHEMICAL EQUIVALENTS OF COPPER AND SILVER.

By Theodore William Richards, Edward Collins, and George W. Heimrod.

Presented June 14, 1899. Received October 30, 1899.

Four years ago we began an investigation which had as its object the careful study of the well known irregularities of the "copper voltameter" from the point of view of the modern theories of electrochemistry. One reason for this study was the fact that the atomic weight of copper computed from the relation of its electrochemical equivalent to that of silver was noticeably smaller than the atomic weight obtained in this Laboratory by purely chemical methods.* Owing to circumstances beyond our control the completion of the work was postponed far beyond its proper time; but at last it is in a condition suitable for partial publication. The matter was complicated by the discovery of an error in the "silver voltameter," as well as in the "copper voltameter." In the mean time an extremely interesting paper by Foerster and Seidel, and several other valuable contributions by Kahle, Patterson and Guthe, and others, upon allied subjects, have appeared.† These cover a part of the ground occupied by our work, and thereby shorten the present account. The work naturally falls under two headings, because each metal needed its special investigation; and this natural division will be retained in the following description.

I. The Copper Voltameter.

The work of Gore, Lord Rayleigh and Mrs. Sidgwick, Gray, Shaw, Vanni, and Gannon,‡ showed long ago that a side reaction, varying in

* T. W. Richards, These Proceedings, **26**, 240 (1891).

† Foerster and Seidel, Zeitschr. anorg. Chem., **14**, 106–140; K. Kahle, Wied. Ann., **67**, 1 (1899); Patterson and Guthe, Physical Review, **7**, 257 (1898); E. H. Griffiths, Nature, **56**, 258 (1897), etc.

‡ Gore, Nature, **25**, 473 (1882); Lord Rayleigh and Mrs. Sidgwick, Phil. Trans., **175**, 458 (1884); Gray, Phil. Mag., (5), **22**, 389 (1886). also **25**, 179 (1888); Shaw, Brit. Ass. Rep. 1886, p. 318 [Phil. Mag., (5), **23**, 138]; Vanni, Wied. Ann., **44**, 214 (1891); Gannon, Proc. Roy. Soc., **55**, 66 (1894).

prominence with circumstances, vitiates the electrochemical equivalent of copper as it is ordinarily determined. Even a cursory study of these careful investigations shows that the complication arises at the point of contact of the copper cathode with the solution, and that the side reaction has the effect of lessening the amount of copper deposited by the current. With this in mind, we made a systematic investigation of the behavior of copper plates in cupric solutions, which led us to precisely the same conclusions as those attained by Foerster and Seidel in the paper already mentioned. Since these gentlemen have described their work in great detail, an abbreviated statement of our results will suffice.

1. Metallic copper slowly dissolves in an acid solution of cupric sulphate, even when the solution has been freed from air and has been protected by an atmosphere of hydrogen. This conclusion was tested many times, and the losses of weight of the plates were found to be roughly proportional to the respective areas of the plates, if the volume of solution was large.

2. A strongly acid solution does not differ materially in its action from a weakly acid solution; hence neither hydrogen nor SO_4 ions can be responsible for the phenomenon.

3. Other things being equal, the action is proportional to the concentration of the cupric sulphate, being very slight when this is absent, even if much sulphuric acid is present. Hence the cupric ions must be the active agents, and they can only dissolve the copper according to the reaction $Cu + Cu^{++}[+ SO_4''] \leftrightarrows 2\,Cu^{+}[+ SO_4'']$. In a word, cuprous sulphate must be formed.

4. In contact with the air this action naturally takes place more rapidly than in the absence of oxygen. Instead of losing only about 0.004 milligram per square centimeter per hour in a normal solution of cupric sulphate at 20°, as before, the loss was nearly doubled. Evidently the cuprous becomes cupric sulphate in the oxidizing environment, and thus opportunity for further reduction is offered.

5. On the other hand, plates of copper immersed in *neutral* solutions of cupric sulphate always *gain* in weight, becoming coated with a film of cuprous oxide. This is a wholly separate phenomenon, due to the hydrolysis of the cuprous sulphate. Of course this hydrolysis cannot happen in an acid solution; hence copper deposited electrolytically from an acid solution is free from cuprous oxide. Obviously, too, the method of Vanni, which consists in adjusting the amount of acid so that the plates neither gain nor lose, is a device for replacing dissolved copper by an equal weight of cuprous oxide, and hence is very faulty from a scientific point of view.

6. As usual, the speed of these reactions is increased by increase of temperature; and moreover, the amount of cuprous sulphate which determines equilibrium is greater in a hot solution than in a cold one.

7. The addition of such substances as cane sugar, even in large amounts, produces no important effect, for obvious reasons.

8. The addition of much sodic sulphate diminishes the action, evidently by diminishing the number of cupric ions present, according to the law of mass action. In one case the loss was diminished to half its normal amount.

Many of these conclusions are to be found, either implicitly or explicitly, in the older accounts, but the interpretation of the facts is now more illuminating because of the assistance of the dissociation hypothesis. The only authority who denies the solubility of copper in cupric sulphate is Schuster,* whose experiments involved only a very small amount of solution, which evidently required only unimportant amounts of copper for its saturation.

Foerster and Seidel have shown that it is possible to dissolve copper in a hot solution, and crystallize the metal by cooling. With the same idea in mind, we constructed an apparatus somewhat different from theirs, arranged so that this operation may take place continuously, with the production of very pure copper in beautiful minute crystals. A ring-shaped tube was fixed in a vertical plane, one side of the ring being surrounded by a steam-jacket, and the other by cool water. This arrangement naturally kept the liquid filling the tube in constant circula-

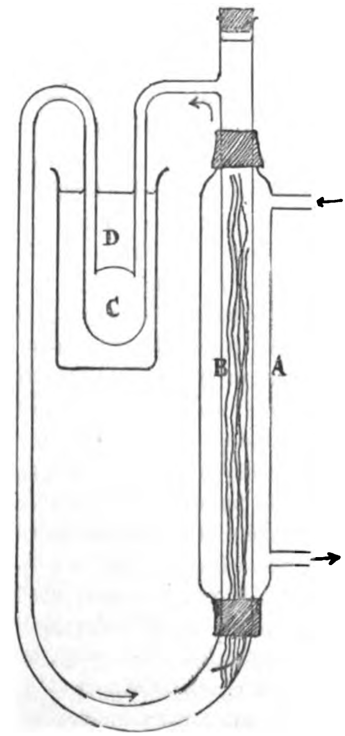

FIGURE 1. — APPARATUS FOR RECRYSTALLIZING METALLIC COPPER.

A, steam-jacket for heating copper. B, copper wires to be dissolved. C, receptacle for crystallized copper. D, cold bath.

* Proc. Roy. Soc., 55, 84 (1894).

tion; and if an acid solution of cupric sulphate is thus made to circulate over copper placed in the hot side, considerable amounts of copper may be dissolved with ease. The crystals deposited upon cooling in the cold limb cling loosely to the glass. A more advantageous form of this device is shown in the foregoing illustration.

From these facts concerning the action of copper on a solution of cupric sulphate, the precautions necessary for obtaining the weight of deposit which most nearly represents the true electrochemical equivalent are evidently the following: —

1. The solution must be as cold as possible.
2. The solution must be acidified, to avoid hydrolysis.
3. The solution must be as dilute as is compatible with the transportation of the required strength of current to a given electrode without risk of deionizing hydrogen. The smaller the electrode, the stronger is the necessary solution.
4. Air must be excluded.

Since even at the freezing point of the saturated solution the action still takes place, although to a greatly diminished degree, the complete fulfilment of these conditions will still yield too small a deposit of copper. In order to overcome the difficulty, Foerster and Seidel * have recommended the saturation of the solution with cuprous ions in the first place; but this plan oversteps its mark, and forms almost the only piece of faulty logic to be found in their paper. Obviously if cuprous ions were the only ones present, twice as much copper would be deposited with a given current as with pure cupric ions. It is well known that when a mixture of metals is present, that substance is deposited which gives the lowest contact-potential with the solution, provided the current is weak and the solution strong. It is easy, however, to deposit brass from a suitable solution of zinc and copper sulphates with a strong current. The present case presents some analogies to this example; but to it is added the proviso that the ions are convertible into one another, and that the cupric and cuprous salts must be present in a ratio definite for each concentration. If some of the cupric salt is removed, for example, less cuprous salt is capable of existing in the solution, and extra copper must necessarily be deposited in order to establish the equilibrium, according to the equation $2\,Cu^{+} \rightleftarrows Cu^{++} + Cu$. Experimental verification of this reasoning will be given later.

We are then between Scylla and Charybdis, — from a cupric solution

* Zeitschrift für anorg. Chem., **14**, 137 (1897).

the deposit must be too small, while from a cuprous solution the deposit must be too large. Both errors decrease as the temperature decreases; but it is evidently impossible to obtain results directly with the copper voltameter which will exactly correspond with the atomic weight of copper, except by a chance combination of circumstances. This combination would be attained when the amount dissolved from the cathode by the side reaction $Cu^{++} + Cu \rightleftarrows 2\,Cu^{+}$ just equalled the extra amount of copper deposited from the trace of cuprous salt in the solution. Such a fortuitous condition could not be maintained for any length of time, because the amount of cuprous salt present must steadily increase by the action at the cathode as well as at the anode. At first sight, it might be supposed possible to increase the current density to such an extent that all the copper in the neighborhood of the cathode should be completely deionized; but it will be shown that hydrogen begins to be deposited instead of copper before this point can be reached.

Besides these sources of error another may exist, to which Foerster and Seidel have called especial attention. This fourth error consists in the possible semi-deionizing (or partial reduction) of the cupric salt by the electric current without the deposition of metal. Thus positive electricity may make its exit from the solution without a corresponding increase in the deposit, and the observed atomic weight of copper will be too low. Evidently, however, this action cannot result in the formation of more cuprous salt than the small proportion corresponding to its equilibrium with the cupric remaining in the neighborhood. Hence this fourth cause of error is essentially identical with the first, the simple dissolving of copper in cupric sulphate. The question then arises as to whether or not the equilibrium is established more quickly under the influence of the current than without the assistance of outside electromotive force. Both Gore and Gray, in the papers already cited, give evidence showing that reasonably small current-densities tend to increase the apparent corrosion of the copper rather than to diminish it. This might have been predicted, for it is easy to imagine that the equilibrium is established more quickly with the help of nascent cuprous ions than with the resting metallic surface of the copper plate. The authors just cited give no evidence to prove, however, that a strong current causes a less proportionate gain in weight than a weak one; indeed, Gray contends that a strong current may even *protect* the electrode from corrosion.*
The phenomena which led him to this conclusion will be shown later to be due at least in part to another cause.

---

* Phil. Mag., (5), **25**, 182 (1888).

The only possible method of determining the amounts of these various modifying effects seems to be to vary the size of the exposed surface of cathode; for upon the extent of this exposed surface depend the most serious causes of error. This mode of experimentation was adopted by Shaw, and especially by Gray in the paper just cited. Gray's results are so interesting that it seems worth while to repeat a part of the plate which depicts his observations. The abscissæ register the number of square centimeters area per ampere, while the ordinates give the values proportional to the amount of copper deposited by a given current in a given time. The solution of cupric sulphate had a specific gravity varying from 1.15 to 1.18, or contained perhaps 250 grams of crystallized salt to the litre.

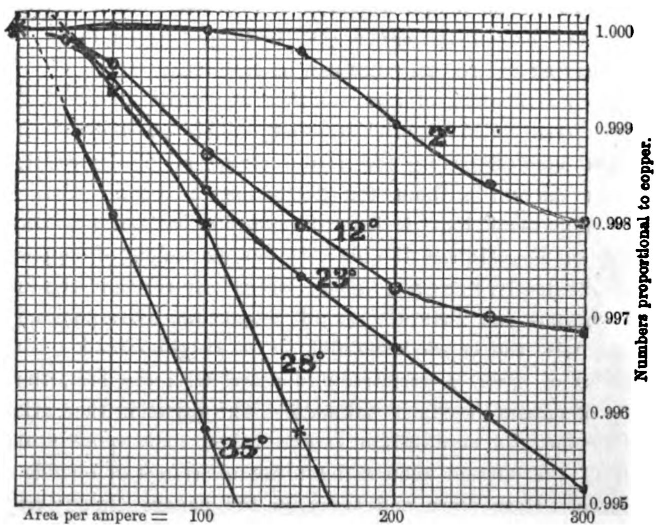

FIGURE 2.—DIAGRAM DRAWN FROM THE NUMERICAL TABLE GIVEN BY GRAY. (Phil. Mag., [5], 25, 182 [1888].)

It is evident that with large areas of cathode (small current densities) the fairly straight lines tend to converge at a point somewhat above the top of the table. On the other hand, when the current density becomes great, the curves fail of their mark and bend sharply to the left. Gray dismisses this remarkable tendency with the assumption of the "protective action" of strong currents already mentioned, and takes as the true value the results obtained at 2° Centigrade with current densities higher than 0.01 ampere per square centimeter.

Since it is precisely this variation of the highest values for copper which interests us, — for we know that the lower values are certainly too low, — it seemed desirable to obtain further light upon this question. We therefore carried out a similar series to Gray's, using weaker solutions, with which the point of inflection in the curve would naturally come at a lower current density. Cathodes and anodes of copper of different sizes were placed in separate portions of a solution of cupric sulphate containing 100 grams to the litre, and the same current was run through the series of cells. The amounts of copper thus deposited are given in the following table.

No. of Analysis.	Strength of Current.	Area of Cathode 50 sq. cm.	Area of Cathode 25 sq. cm.	Area of Cathode 12½ sq. cm.
	Ampere.	Grams.	Grams.	Grams.
a	0.12	0.07325	0.07341	0.07345
b	0.19	0.66856	0.66909	0.66921
c	0.21	0.44460	0.44469	0.44462
d	0.22	0.31212	0.31225	0.31204
e	0.25	0.45869	0.45918	0.45907

The first fact which is at once apparent is the interesting phenomenon of a *decrease* in the deposit on the smallest plate in experiments *c*, *d*, and *e*. This corresponds to a downward turn in Gray's curve; and if these results are plotted upon his scale, the following diagram is obtained. (See Figure 3, on the next page.)

Such a curve as this is only to be produced by the appearance with high current densities of another cause, independent of the cuprous-cupric reaction, but also tending to lower the observed weight of copper. It is not difficult to suggest what this cause may be. When the current increases in strength, the copper ions in the neighborhood of the cathode are no longer able to carry all of the current, and a portion of the load is taken by the only other positive ion present. But the hydrogen which thus plays the electrical rôle of the copper weighs far less than the equivalent weight of the red metal. A small amount of hydrogen, capable of being occluded by the copper without change in the appearance of the surface, would cause an immense deficiency in the gain in weight. When the current strength increases only a little above 0.02 ampere per square centimeter the deposit of the copper becomes powdery, probably because

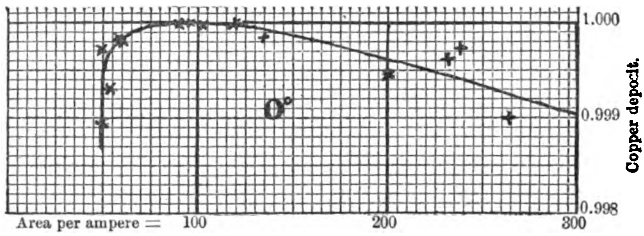

FIGURE 3. — DIAGRAM SHOWING DECREASE IN COPPER WITH SMALL CATHODES (DUE TO HYDROGEN).

The table above is here plotted by taking the highest weight of copper in each determination as unity. Great exactness could not be expected from this method, but it is sufficiently definite to show a marked deflection of the line when the 100 sq. cm. line is approached, and a sudden downward tendency when the current density approaches 0.02 ampere per square centimeter.

of the action of the occluded hydrogen, and the deficiency assumes gigantic proportions. Indeed it has been well known for a long time that this current density is the limit if one makes any pretence to accuracy; our results merely show that the action of the hydrogen begins to affect the deposit long before it becomes manifest to crude observation. Thus it seems probable that the left-handed tendency of Gray's curves, instead of being due to the approach to the true value and a lessening of the corrosion, was really due to the beginning of a new source of inaccuracy. From a theoretical standpoint such a phenomenon appears only natural; with more dilute solutions the deficiency would of course appear at lower current densities. Probably the fact that in analytical work the amount of the deposited metal never corresponds to the quantity of electricity may often be due to the same cause, in addition to the oxidizing action pointed out by Danneel.*

Returning now to weaker currents in fairly strong solutions (Experiments *a* and *b*), it is evident both from Gray's results and from our own that the weight of the deposit in this case is approximately a linear function of the area of the cathode; in other words, the dissolving of copper in cupric sulphate is approximately proportional to the surface of copper exposed, even while the current is running. Since this is the case, the obvious method of obtaining the true weight of copper would be to extrapolate for a surface of zero area, — or to add to the weight deposited upon a medium-sized area the difference between its gain and

* Zeitschr. Electrochem., 4, 158 (1898).

the gain on an area of twice the size. This method of correction would certainly give a correction which is too large, for during the electrolysis the solution is steadily approaching saturation with cuprous ions, which are deposited but not accounted for by the correction. Nevertheless it was decided to carry out a series of observations with plates of two sizes, calculating the results according to this method of correction, and comparing both corrected and uncorrected values with the results of an included silver voltameter. In this way an upper and a lower limit for the electrochemical equivalent of copper might be fixed; and by using a low temperature, it seemed probable that the two limits might be brought near together. Agitation would of course increase the amount of corrosion * and diminish the error due to hydrogen; but we preferred to use low current densities and rely upon the natural convection of the electrolyte, which is then sufficient if the error is kept low by cold.

Experimental Details.

The cupric sulphate used for the following experiments, after having been purified in usual ways, was allowed to stand for some time, first with flocculent cupric hydroxide and then with pure copper, in order to free it from possible traces of bismuth, silver, etc. Subsequently it was recrystallized from the purest water. Metallic copper for the anodes was prepared by electrolysis from this material, after strongly acidifying its solution with pure sulphuric and nitric acids.

The silver used for the anodes was prepared according to the well known chloride-milk-sugar method of Stas, and was amply pure enough for its purpose. The argentic nitrate used as an electrolyte was made from this silver by the action of pure nitric acid. This salt was recrystallized, dried, and fused in order to insure its neutrality. For particulars concerning these and other precautions, the reader is referred to recent papers upon the atomic weight of copper and other atomic weights.†

In any given experiment, the galvanic current was sent through two silver and at least two copper cells, all being arranged in series in such a way as to avoid liability to leakage. Every point of contact with the desk was amply insulated by glass plates, and the wires were arranged as much as possible in air-lines.

The copper cells were contained in wide-mouthed bottles with a capacity of 500 cubic centimeters each, provided with well cleaned rubber

* Compare Foerster's results.

† These Proceedings, **22**, 342 (1887), **23**, 177 (1887), **25**, 95 (1890), **26**, 240 (1891), etc.

stoppers. Through these stoppers ran the tubes for supplying the hydrogen used to exclude oxygen from the process, as well as the sup-

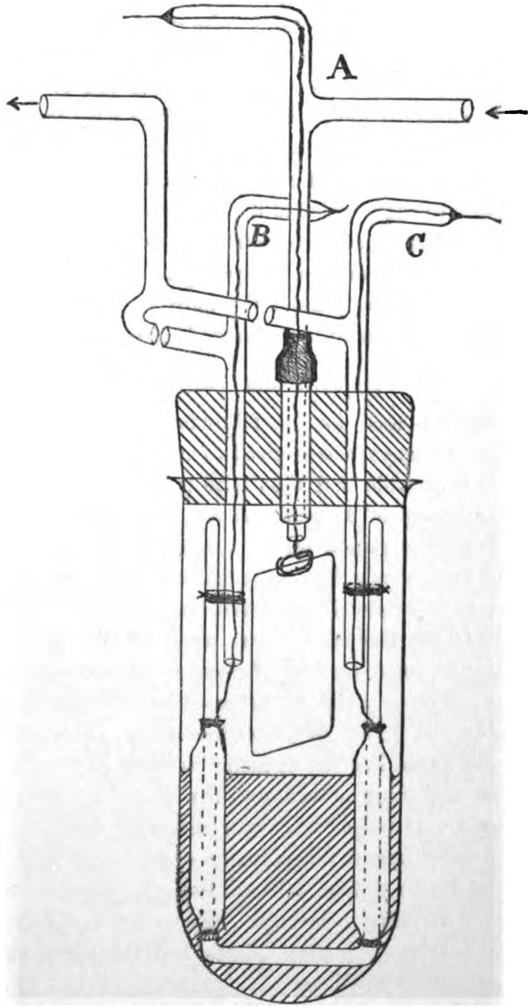

FIGURE 4.

ports for the electrodes. Two anodes (B and C) were used in each cell, and in all except the earliest experiments the cathodes (A) were of platinum. A diagram, Figure 4, while illustrating a later modification,

sufficiently explains the arrangement. At the close of an experiment the cathodes were immediately immersed in water, and after a thorough washing in pure water and alcohol were dried as usual. The electrolyte contained 100 grams of crystallized cupric sulphate in a litre.

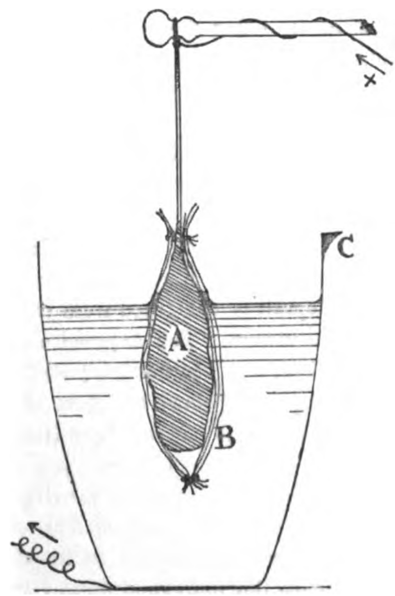

FIGURE 5. — COMMON SILVER VOLTAMETER (½ natural size; section).

A, silver anode. B, filter paper covering. C, lip of platinum vessel forming cathode.

The silver cells were essentially similar to those used by Lord Rayleigh, except that the cathodes consisted of large light platinum crucibles instead of bowls. These crucibles weighed only 60 grams, although they were capable of holding 120 cubic centimeters; they were provided with lips. A crucible exposes a smaller surface to the impurities of the atmosphere and gave in our experiments a more evenly distributed deposit than a bowl. The anode consisted of a lump of pure silver, wrapped in pure filter paper, and the electrolyte contained ten per cent of argentic nitrate. When the current was stopped the argentic nitrate was decanted through a weighed Gooch crucible, and, after standing many hours with several fillings of pure water, the crucibles were washed with pure water and alcohol, and dried at 130°. The decantates were filtered, in order to be sure that no silver had been lost; if the Gooch crucible was found to contain any of the deposit, its weight was added to that of the greater part clinging to the cathode. In one or two of the earlier determinations, plates were used instead of crucibles as cathodes; but since the results thus obtained showed no systematic variation from those with the crucibles, the table is not complicated by calling attention to this inessential fact. The danger of losing silver mechanically from the corners of a plate is so great that this form of cathode was soon abandoned.

In the table on page 135, each horizontal line reports a complete experiment, which usually required a day for preparation and another for accomplishment. At first the copper cells were multiplied; but later when the silver seemed to be quite as uncertain as the copper, the nobler metal received its full share of representation. Some of the earlier experiments failed for one reason or another, and these failures are not included in the table. The last six determinations were consecutive; and in these the conditions of experiment were much more satisfactory than in the earlier ones; for much practice was naturally acquired in the course of the work. In all the experiments excepting Nos. 1 and 2 the cupric electrolyte was boiled and cooled to zero in an inert atmosphere before the electrolysis; and in all excepting Nos. 1, 2, 3, and 6 the copper electrolysis was conducted in an atmosphere of hydrogen.

Attention is again called to the fact that each corrected value for the copper deposit is computed from two deposits, one on a large and one on a small electrode. The exposed area of the large electrode was always about 50 square centimeters; and in all cases, except those indicated by the signs †‡ below, the area of the smaller plate was half that of the larger. The current densities varied slightly, but were always less than 0.01 ampere per square centimeter on the smaller plate, the total current strength usually being about 0.12 ampere for the system. When the total current strength was kept below this limit, no systematic variation due to its changes could be detected in the results; hence the individual figures are omitted in this published account. In order to prevent saturation with cuprous salt, the volume of the electrolyte used in each cell was fairly large, being usually about 200 cubic centimeters.

The corrected average value from the table for the atomic weight of copper, 63.563, has a "probable error" of 0.004 as far as the accidental inaccuracies of manipulation are concerned. It has already been shown, however, that a value obtained in this way must correspond to a deposit of copper slightly too great; for the mode of correction does not take account of the growing, although slight, presence of cuprous salts. On the other hand, the values computed from the directly observed quantities of copper must be too small. The average observed values, calculated from the sums at the bottoms of the respective columns, are Cu = 63.525 from the larger plates, and Cu = 63.547 from the smaller plates. It is evident then, that the true electrochemical atomic weight of copper, when compared with the silver deposited in the ordinary silver voltameter, must lie between the limits 63.563 and 63.547. It

Comparison of the Silver with the Copper Voltameter.

Temperature of Silver Voltameter = 15° to 25°. Temperature of Copper Voltameter = −2° to 0°.

	Large Copper 50 sq. cm.	Small Copper usually 25 sq. cm.	First Silver (in air).	Second Silver (in air).	Corrected Copper.	Average Silver. (cor. to vac.)	Atomic Weight of Copper, Ag = 107.93.
1	0.44460	0.44469	1.51039	1.51098	0.44478	1.51064	63.56
2	0.31555*	0.31623*†	1.07476		0.31645	1.07473	63.56
3	0.24965*	0.24967*†	0.84780	0.84808	0.24968	0.84792	63.56
4	1.02182*	1.02189	3.47066		1.02186	3.47056	63.56
5	0.66090*	0.66128*	2.24545		0.66166	2.24538	63.61
6	0.62992*	0.63018†	2.14008	2.14105	0.63027	2.14050	63.56
7	0.45869	0.45907†	1.56000		0.45919	1.55995	63.54
8	0.39140	0.39165‡	1.33075		0.39177	1.33071	63.55
9	1.11054	1.11042	3.76996	3.77003	1.11030	3.76990	63.57
10	0.67592	0.67578	2.29667	2.29655	0.67564	2.29655	63.51
11	0.48238	0.48235	1.63731	1.63816	0.48232	1.63768	63.58
12	0.83036	0.83064	2.82200	2.82222	0.83092	2.82203	63.56
13	0.63407	0.63449	2.15780	2.15701	0.63491	2.15735	63.53
14	0.69956	0.70029	2.37916	2.37840	0.70102	2.37868	63.61
15	0.84341	0.84375	2.86580	2.86654	0.84409	2.86608	63.57
16	0.87448	0.87455	2.97121	2.97126	0.87462	2.97114	63.54
17	0.69379	0.69392	2.35652	2.35729	0.69405	2.35683	63.57
	11.01704	11.02085			11.02363	37.43593	63.563

* These determinations were made in duplicate. Thus, in Experiments 2, 3, and 5, four copper cells were in the current at once. The pairs agreed within themselves remarkably well, the average deviation from the mean being only 0.03 milligram.

† In these experiments, the smaller copper was ¼ as large as the larger one.

‡ In this determination the smaller copper was ⅛ as large as the larger one.

is to be noticed that the value (63.54) obtained from Gray's observations by our method of correction is near these figures.*

If the absolute accuracy of Faraday's law is assumed, these results show either that the silver voltameter must yield nearly 0.1 per cent too much silver, or else that the value of the atomic weight of copper found chemically in this Laboratory (63.604) must be 0.1 per cent too high.

Convincing as these conclusions seemed, the attempt was made to obtain yet further light upon the copper voltameter by varying the conditions. For example, several experiments were made with a mercury cathode, in the hope that the amalgam of copper might be less easily influenced by side reactions than the metal itself; but the difficulties in the way of determining accurately the weight of the large volume of metal which was needed to contain the copper, soon led to the abandonment of this attempt. Moreover other chemical difficulties, due to the possible dissolving of mercury, added complications.

It seemed now worth while to make a few determinations of the amount of copper deposited from a solution *saturated* with cuprous salt, in order to fix the highest possible limit for the electrochemical equivalent in a fashion wholly free from any correction, as well as to test experimentally our criticism of Foerster and Seidel's remarks about such a solution. In order to saturate the liquid with cuprous ions, the weighed platinum cathode was raised above the solution by means of its sliding support, and the current was run backward and forward for an hour or more between the two coils of copper (wrapped in filter paper, B and C, Fig. 4) which were to serve as anodes. Instead of the large bottle of the earlier experiments, a test tube just large enough to contain the electrodes was used, so that the small amount of necessary solution could be more easily saturated. In due time the cathode was lowered, and the quantitative electrolysis commenced. Of course the solution had been boiled, and was protected by a current of hydrogen throughout the experiment. The silver voltameter used was an improved arrangement, but its results are reduced to the standard used in the earlier experiments for the sake of ready comparison. This matter will be fully explained in the sequel.

This value of the atomic weight, 63.573, is 0.06 per cent higher

---

* Gray in his first paper reports that with plates of 240 sq. cm. area he obtained 0.29303 gram of copper for every gram of silver, while with plates of 50 sq. cm. area he obtained 0.29407 gram. Hence with plates of zero area he would have obtained 0.29434, corresponding to the atomic weight given above. (Phil. Mag., [5], **22**, 407 [1886]. Last three determinations in table.)

COMPARISON OF THE ORDINARY SILVER VOLTAMETER WITH THE COPPER VOLTAMETER SATURATED WITH CUPROUS SALT AT 0°.

	Weight of Copper (in Vacuum).	Weight of Silver (in Vacuum).	Atomic Weight of Copper.
24	0.71847	2.43935	63.578
25	0.71861	2.43940	63.585
26	0.72019	2.44603	63.556
27 *a*	0.97193	3.30100	63.558
28	0.50916	1.72859	63.582
29 *a*	0.76188	2.58664	63.580
	Average		63.573

than the average of the forty observed results in cupric solutions, and 0.016 per cent higher than these results after correction. As far as the copper deposit is concerned, this result is certainly the upper limit of the electrochemical value, although it is still below the chemical atomic weight. No experimental proof has yet been given that too much copper was deposited, however.

If the cuprous salt really carries a part of the current, it is obvious that higher temperatures, involving the presence of more cuprous salt, should raise the observed value still higher. This matter is tested in the results which follow.

COMPARISON OF SILVER VOLTAMETER WITH COPPER VOLTAMETER SATURATED WITH CUPROUS SALT AT HIGHER TEMPERATURES.

No of Experiment.	Temperature.	Weight of Copper (Vacuum).	Weight of Silver (Vacuum).	Atomic Weight of Copper.
27 *b*	61°	0.97295	3.30100	63.62
29 *b*	55°	0.76214	2.58664	63.61

This gain in the apparent atomic weight, from 63.573 to 63.615, is conclusive. Even without further knowledge of the silver voltameter one is able to predict with reasonable certainty that higher temperatures

should yield yet higher values, and hence that the presence of cuprous salt really causes the deposit to be too heavy.

The results of all these varied operations assign a wide range of apparent values to the atomic weight of copper. In order to present the matter in a nutshell, a table is given below.

Uncorrected results of Rayleigh, Gray, Shaw, Vanni, etc.			. .	63.30 to 50
Large plates in cupric solutions,	20°	(present research,)	. .	63.47
" " " "	0°	" "	. .	63.525
Small " " "	"	" "	. .	63.547
Medium plates, in cuprous solutions,	0°	" "	. .	63.573
" " " "	60°	" "	. .	63.615
Corrected results from cupric solutions,			. . . .	63.563
Atomic weight of copper by chemical processes,			. . . . . .	63.604
		Discrepancy	. .	0.041

It has already been stated that the corrected value is probably a little too high, although it is still nearly 0.07 of one per cent below the chemical value. This discrepancy, taken in connection with the inexplicable variations in the results of parallel determinations with the silver voltameter (see page 135), led us to suspect this instrument long before the results given above were completed. Accordingly, many of the electrolyses which we have been discussing were also used as a means of testing the accuracy of the silver voltameter. The overlapping investigations have been separated in the description only in order to make a very complex matter less obscure to the reader. The outcome of the experiments upon the silver voltameter is explained below.

II. The Silver Voltameter.

The inference to be drawn from the preceding work is that the amount of silver deposited in the silver voltameter, as described by Lord Rayleigh and Mrs. Sidgwick * in their classical paper, may be too great by nearly 0.1 per cent. In spite of the great care taken by these investigators, such a deviation from the exact value is not impossible; and indeed Lord Rayleigh does not claim for this work an accuracy over 0.1 per cent.

The first possible cause of error to be investigated was the possible occlusion (or rather *inclusion*) of electrolyte by the crystalline deposit.

* Phil. Trans., 2, 411 (1884).

Lord Rayleigh did not neglect this source of error, and by some very ingenious qualitative experiments showed that it could not be large. It seemed to us worth while, however, to analyze quantitatively the precipitated silver, and the following table recounts this series of trials, in which the silver was dissolved, and precipitated by the purest hydrobromic acid with great care.*

No.	Silver taken (Vacuum).	Argentic Bromide obtained (Vacuum).	Silver calculated from AgBr.	Deficiency in Silver.	Percentage Deficiency.
30	0.71585	1.24567	0.71573	+0.00012	+0.017
31	5.43807	9.46557	5.43747	+0.00060	+0.011
32	3.76993	6.56216	3.76961	+0.00032	+0.008
33	2.29649	3.99820	2.29674	−0.00025	−0.011
34	2.15701	3.75473	2.15689	+0.00012	+0.006
35	2.37893	4.14187	2.37928	+0.00035	+0.015
36	2.97120	5.17218	2.97114	+0.00008	+0.003
					+0.007

The result of this table somewhat surprised us; for few crystalline precipitates contain so little included mother liquor as 0.01 per cent. While the analytical work is not perfect, (for the result of Experiment 33 can only be ascribed to accident,) one is forced to conclude that the precipitate is very nearly pure silver. Evidently the electrical method of precipitation insures a more compact structure than is possible when the precipitation does not involve outside electromotive force. One of us found three times as much water in crystallized silver prepared at 0° in another way.† The source of error in the voltameter is apparently more subtle than such a merely mechanical cause as inclusion.

Further experimentation upon such silver deposits showed that, after having been properly washed, they neither gained nor lost in weight upon continued digestion with water or with neutral solutions of ar-

* For the method, consult recent papers on atomic weights from this Laboratory.

† These Proceedings, **23**, 177 (1887).

gentic nitrate, hence any possible error must have crept in during the electrolysis.

The existence of flaws in the working of the silver voltameter is no new idea, and a brief résumé of earlier anomalies is necessary in order to indicate our own train of thought.

Lord Rayleigh and Mrs. Sidgwick found that large cathodes yielded higher results than small ones, and warm solutions yielded higher results than cold ones. In some cases the deviations amounted to 0.1 per cent.

Schuster and Crossley * state that deposits made in a vacuum are slightly heavier than those produced by the same current in air, and these in turn are heavier than those produced in an atmosphere of oxygen. Myers † verified these statements. Schuster and Crossley showed also that with great current density argentic peroxide may form at the anode, and in some unexplained fashion the result is a diminution of the weight of the silver deposited; moreover, they pointed out the fact that the discrepancies observed by Lord Rayleigh and Mrs. Sidgwick between large and small bowls disappear when the anodes are of the same size. Apparently "*the anode gives rise to secondary reactions.*"

Rodger and Watson ‡ observed that on continued use of the electrolyte the deposits grow heavier; and they also found that, when a very strong slightly acidified solution of argentic nitrate was electrolyzed by a powerful current, the acid was removed, and the deposit was much too heavy. They venture to say that a subsalt of silver is formed "having a silver ion heavier than the argentic salt."

Again, Kahle § has found that after boiling the electrolyte with oxide of silver, the deposit is increased 5 parts in 10,000. In a later and very important paper ‖ he calls attention for the first time to the fact that in a dilute electrolyte an acid is formed during the electrolysis. Furthermore, he shows again that old solutions give too high results, an error which was sometimes removed by treatment with argentic oxide. Colored spots sometimes appeared upon the silver in old acid solutions, apparently caused by the liquid descending from the anode; these did not form in a neutralized solution, or in one which had been allowed to remain in contact with silver. Kahle's hypothetical explanation of these phenomena essentially agrees with Rodger and Watson's.

* Proc. Roy. Soc., **50**, 344 (1892).

† Wied. Ann., **55**, 288 (1895).

‡ Phil. Trans., **186** A, 631 (1895).

§ Brit. Ass. Adv. Sc. Edinb. (1892), p. 148.

‖ Wied. Ann., **67**, 1 (1899), or Zeitsch. f. Instrkunde, **18**, 229, 267 (1898).

The latest work which has come to our notice is that of Patterson and Guthe.* In this paper the authors give the lion's share of their attention to an admirably worked out treatment of the physical methods necessary for fixing the electrical units, and pay little heed to the chemical side of the question. Since they obtained constant results by treating their electrolyte with argentic oxide, they recommend this method for general use, in spite of the fact that both Rodger and Watson and Kahle have shown that such treatment probably yields too high results.

The essence of all these investigations, as far as they concern the irregularities of the silver voltameter, may be summed up in the following words.

A substance which causes the deposition of too much silver seems to be formed around a large anode. Oxygen tends to eliminate this substance, hence the substance must be a reducing agent. All the phenomena agree with this interpretation. A very small anode (which causes another irregularity, namely, the formation of argentic peroxide) may result in the appearance of a lower weight of silver; perhaps argentic peroxide may oxidize the reducing substance and thus remove it. The formation of the reducing substance is accompanied by the liberation of hydrogen ions in dilute solutions of argentic nitrate; but in stronger solutions small amounts of acid may be neutralized. In warm solutions the reducing agent is somewhat more active than in cold.

An important point is left in doubt: — Does the acid appear at the anode or the cathode? Nothing could be easier than to answer this question; and a large number of trials in which the anode was enclosed in a porous cup showed conclusively that the acid was always formed at the positive pole. The solution around the cathode remained wholly neutral to methyl orange, while the liquid within the cup gave a strongly acid reaction.

In marked contrast with the case of copper, the chief disturbing reactions seem then to exist at the point at which the positive electricity enters the solution; and the obvious remedy for the irregularity is to enclose this positive electrode in a cell which will permit conductivity but will shut out convection.

Experimental Details.

Small cylinders of Pukal's porous ware (Berlin), such as are used for osmotic pressure experiments, were found to serve admirably as the

* Physical Review, 7, 251 (1898).

permeable septum desired. These vessels were 50 millimeters high and 20 in diameter; their walls were not much over one millimeter in thickness. Their impurities were removed by boiling with nitric acid and thorough washing with water. They were suspended in the solution by means of a platinum wire hung upon a glass hook, which insulated the wire from the electric connections. In four experiments two concentric porous cups were used, the annular space between them being charged with argentic oxide, since Kahle found this substance to diminish the reducing action in old solutions. This last arrangement was soon abandoned, however. By means of a siphon the liquid within the cup was always kept at a lower level than that without, so as to prevent outward filtration.

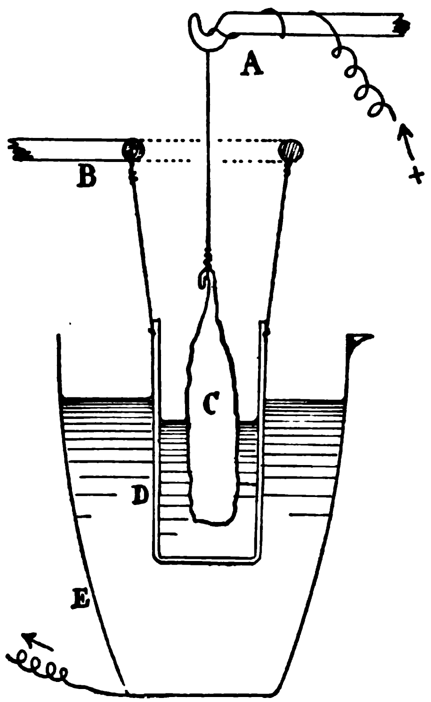

FIGURE 6. — POROUS CUP VOLTAMETER (¾ actual size).

A, glass hook for supporting anode. B, glass ring for supporting porous cup. C, silver anode. D, porous cup. E, platinum cathode.

The cathodes consisted of the large lipped crucibles already described; the anodes were bars $5 \times 1 \times 1$ centimeters of the purest silver, supported by silver wires and not enclosed in filter paper; and the electrolyte usually contained 10 per cent of pure freshly prepared argentic nitrate.

The temperature of the cell under investigation was kept constant by means of suitable baths. For a low temperature a mixture of pure ice and a solution of ammonic nitrate answered well, and for the higher temperatures a large beaker containing pure water was warmed from the outside by enough encircling leaden steam-pipe to cause the desired intensity of heat.

The manipulation was simple. The platinum crucibles were cleaned, dried at 160°, and weighed after two or three hours' cooling in a large desiccator kept in the balance-room. In order to prevent leakage during the electrolysis, the several stands were insulated by separate glass plates, and all the connections were air lines. The apparatus was protected, as in the earlier experiments with copper, by a miniature house with walls of fine cotton cloth, which helped to exclude dust. When the current was broken, the electrolyte was removed, the silver was rinsed twice with water, a third filling with water was allowed to stand in the crucible for two or three hours, and a fourth one remained in it over night. The wash-waters were collected and filtered if the silver showed any tendency to break off. In such cases a Gooch crucible was employed to collect the particles; and a very small filter, afterwards burned, served to catch the minute flakes of asbestos detached from the mat. On the next morning, the crucibles were washed once more, rinsed twice with pure alcohol, and finally dried and weighed as before. This method of treatment gave opportunity for the diffusion of mother liquor from the intricate recesses of the crystallized mass, while it did not run the risk of dissolving silver which may attend the use of boiling water for washing. It is probable that traces of water remained even after drying at 160°, but the experiments on page 139 show that these traces were less than one part in ten thousand.

Weighings were made upon the balance which served for the weighings in the earlier work upon copper, — one which has served also for many determinations of atomic weights. Its results with small objects may be depended upon to within $\frac{1}{50}$ milligram. All weighings were made by double substitution, a similar vessel being used as a tare, and the weights were of course carefully standardized. Since the question concerned merely the comparison of silver with silver, the results were not corrected to the vacuum standard.

The object of the work described below was to determine the relative values given by the silver voltameter under different conditions, and to interpret the results in such a way as to point out the true value. For such a purpose it is convenient to select some one method as a standard of reference; and because the porous cup method, conducted at 20°, soon showed itself to be capable of giving the most constant results of all the various modes of procedure, it was chosen as this standard. For example, in one case a given current caused depositions of 2.43744 and 2.43749 grams of silver in two cells placed in series, — a difference of only 2 parts in 100,000.

THE SILVER VOLTAMETER UNDER VARYING CONDITIONS.

Number of Experiment.	Weight of Silver (standard). Cell at 20°-25°.	Weight of Silver in Voltameter to be tested.	Difference.	Ratio of standard Silver to heavier Silver.	Method used in Voltameter to be tested.
	Grams.	Grams.	Milligrams.		
37	1.94124	1.94267	1.43	1.00074	Cathode a lipped crucible; anode wrapped in filter paper; precisely like the cell used in preceding copper work.
38	1.76283	1.76425	1.42	1.00080	
39	3.04996	3.05270	2.74	1.00090	
			Average =	1.00081	
40	3.09629	3.09918	2.89	1.00094	Lord Rayleigh's method. Cathode a bowl; anode a plate in filter paper; at 20°±.
41	2.53256	2.53439	1.83	1.00072	
			Average =	1.00083	
42	2.53256	2.53357	1.01	1.00040	The same at 0°.
				[1.0012]	The same warm.*
43	2.55012	2.55460	4.48	1.00176	Patterson and Guthe's method: old electrolyte saturated with Ag_2O.
44	1.89800	1.90238	4.38	1.00230	
			Average =	1.00203	
45	2.44412	2.44599	1.87	1.00077	Cathode a crucible. Anode enclosed in porous cup like standard, but temperature 60° (instead of 20°).
46	3.29842	3.30036	1.94	1.00059	
			Average =	1.00068	
47	2.63668	2.63822	1.54	1.00058	Like the above, except that two porous cups packed with Ag_2O isolated the anode (60°).
48	1.72724	1.72724	0	1.00000	
49	2.58463	2.58663	2.00	1.00078	
50	3.09629	3.09988	3.59	1.00116	
			Average =	1.00063	
51	2.55012	2.55029	0.17	1.00007	Cathode a crucible. Anode enclosed in porous cup like the standard. Temperature 0°.
52	1.89800	1.89845	0.45	1.00024	
			Average =	1.00016	

* From Lord Rayleigh's figures.

With this cell were compared the following modifications of the silver voltameter: first, the large crucible voltameter at 20°, with the anode wrapped in filter paper, such as was used in the preceding experiments upon copper; secondly, a voltameter at 20° prepared according to Lord Rayleigh's standard prescription (a platinum bowl, 10 centimeters in diameter, containing a 15 per cent solution of argentic nitrate and a large silver plate enclosed in filter paper); thirdly, the same arrangement at 0°; fourthly, an exact imitation of Patterson and Guthe's method, for which the electrolytes used in Lord Rayleigh's method were digested with argentic oxide and filtered; fifthly, the "porous cup method" at 60° instead of at 20°; sixthly, the same with a double porous cup enclosing argentic oxide in the annular space; and finally, the "porous cup method" at 0°. The table opposite explains itself.

Discussion of Results.

The comparison of these results is highly instructive. The most noticeable fact is that our "standard porous cup method" gives the lowest result of any of the methods tried, since all the figures in the fifth column are greater than unity. In the next place, we find that Patterson and Guthe's method gives a result 0.12 per cent higher than Lord Rayleigh's; a figure which corresponds closely with their own estimate, 0.11 per cent, while Lord Rayleigh's method gives results 0.082 per cent higher than ours. Evidently the method used in the first three experiments is essentially similar to Lord Rayleigh's, and may be averaged with it. Again, it is apparent that the interposition of argentic oxide in the hot determinations had a varying and unsatisfactory effect, as if it introduced a new source of error. Finally, it appears that change of temperature causes a somewhat smaller variation in the results from the "porous cup method" than in those from Lord Rayleigh's old standard: —

	Lord Rayleigh's Voltameter.	Porous Cup Voltameter.
60°	1.0012 (?)	1.00068
20°	1.00083	1.00000
0°	1.00040	1.00016

The obvious inference from these facts is that the porous cup is really effectual in protecting the cathode from a part at least of the disturbing influences under consideration, especially at low temperatures. The apparent *gain* of 0.016 per cent exhibited by the method at 0° was undoubtedly due to the difficulty in washing the very finely divided spongy metal which is deposited from a freezing solution; but Lord Rayleigh's

method at 0° is affected by the same source of error, so that the comparison is a fair one.

The only alternative to this inference, — the supposition that the porous cup introduces a new complication causing too low a weight, — is difficult to disprove; but, on the other hand, the possible nature of such a complication is not easily conceivable.

Recurring to the first inference, an hypothesis supported by many facts, we admit it to be probable that the porous cup does not wholly prevent the admixture of the hypothetical complex ions with the liquid around the cathode; for even if diffusion were wholly prevented, some of these ions might migrate with the current. Both diffusion and migration are increased in rapidity by a rise in temperature, hence even with the porous cup the hot solution gives a somewhat higher value.

It is a matter of great interest to study the effect of the low value obtained by the new method upon the electrical atomic weight of copper, upon the electrolytic value assigned to the ampere, and upon the electrical result for Joule's equivalent.

We concluded, at the close of the section devoted to copper, that the atomic weight of this metal must lie between the limits 63.547 and 63.563, if the common silver voltameter is correct in its verdicts. We have now shown that the results of this voltameter are in all probability too high by 0.081 per cent; hence the conclusion is that the true atomic weight of copper must lie between 63.598 and 63.615. Since the elaborate chemical investigation of copper carried out some years ago in this Laboratory yielded the value 63.604, we have here a remarkable confirmation of the results of the "porous cup voltameter."

In this connection, it is worth while to call attention to the reasons why copper placed in an ice-cold solution of argentic nitrate causes the deposition of the true amount of silver.* Of this automatic voltaic cell the anode is copper; hence the complications which arise around a silver anode do not exist. On the other hand, the cathode is silver; hence the complications which take place around a copper cathode do not exist. The trace of cuprous salt undoubtedly formed at the anode does not decompose the very cold ions of nitric acid, but sooner or later deposits its equivalent of silver. The action is so slow at the low temperature that the current density where the silver is deposited is very small, hence there is no danger of the deposition of a weighable amount of copper

* Richards, These Proceedings, **22**, 342, **23**, 177 (1887).

with the silver; * and the concentration effect prevents the deposition of silver in any place where the silver has become nearly exhausted from the solution.

It is possible to apply a correction to the various values which have been assigned to the electrochemical equivalents of copper and silver with the help of the tables given above.

This computation is made below; it does not pretend to be precise, but will show in a general way the effect of the complications under consideration.

		(Grams per Ampere-second.)
Lord Rayleigh and Mrs. Sidgwick . . .	$\frac{0.0011179}{1.00082}$	$= 0.0011170$ †
Fr. and W. Kohlrausch	$\frac{0.0011183}{1.00082(?)}$	$= 0.0011174$
Kahle (fresh solutions)	$\frac{0.0011182}{1.00082}$	$= 0.0011173$
Patterson and Guthe	$\frac{0.0011192}{1.00203}$	$= 0.0011174$

The average of these results is about 0.0011173, but perhaps 0.0011172 (the mean between the two extremes) is a safer value to choose.

From this value of the electrochemical number for silver, that for copper may be calculated simply by multiplication with the ratio of the chemical equivalents; for we have shown that its true value corresponds to Faraday's law within one part in five thousand. Hence it may be taken as $0.0011172 \times \frac{63.604}{215.86} = 0.0003292$ grams per ampere-second. ‡

* Lord Rayleigh and Mrs. Sidgwick, Phil. Trans., **175**, 470 (1884).

† The probable reason for the lowness of this result is the fact that Lord Rayleigh washed and ignited the silver at high temperatures. All the other values, including our own, may be a trifle high because of traces of occluded mother liquor. No attempt is made at present to correct the results for this possible error. The results of Masquart (J. de Phys., [2], **3**, 283 [1884]), Pellat and Potier (Ibid, [2], **9**, 381 [1890]), Köpsel, Heydweiller, and others are omitted from this table, since they throw no further light chemically. Some are too low and others too high, hence they would not have much effect on the average. Compare Patterson and Guthe's paper.

‡ The value 0.0003294 found by F. E. Beach from a solution containing chlorine is probably affected by the presence of cuprous salts. (Am. J. Sc. [3], **46**, 81 [1893].) All the other directly determined values for this quantity are lower than our value.

Thus 96,610 coulombs correspond to one gram equivalent of an electrolyte.

These numbers are of interest from a theoretical standpoint, but their practical value as means of determining current strength must depend upon the ease of their application. The value for copper is a mean between two limits, and is not easy to reproduce with exactness; but for most purposes the weight deposited by current densities between 0.008 and 0.012 amperes per square centimeter, from ten per cent solutions of cupric sulphate cooled below zero and protected by an inert atmosphere, is sufficiently close to the real value. Nevertheless, empirical tables like those of Gray will probably remain the most convenient method of computing current strength from the deposition of copper.

On the other hand, the intricacy added by the porous cup in the silver determination is not serious, and the results obtained seem trustworthy. Obviously any method capable of being repeated with constant results, when standardized with accuracy by means of known currents, would serve all practical purposes; and a method which is constant because the sources of error have been at least partially removed is certainly worthy of attention.

This point suggests a discussion which has recently arisen concerning the electrical determination of Joule's equivalent, which depends upon measuring the heat corresponding to a known amount of electrical energy. Griffiths, in an appendix * to an elaborate paper † upon this subject, calls attention to the fact that an error in the electrochemical equivalent of silver of 0.1 per cent would explain the difference between his value of the mechanical equivalent of heat and Rowland's. The equation of Griffiths for the calculation of his value is

$$J = \frac{E^2}{RM}\left(\frac{\delta t}{\delta \theta}\right),$$

in which E signifies the constant potential difference, $R =$ the resistance converting electricity into heat, M the heat-capacity which is heated, δt the interval of time, and $\delta \theta$ the change of temperature. The electrochemical equivalent of silver enters into this expression in the determination of the value of E in reference to R. Griffiths's value for J is larger than Rowland's, hence his value for E is greater than that which Rowland would have observed if he had used an electrical method; or, in other words, too small an amount of silver may have been taken as the

* Nature, 56, 258 (1897). † Proc. Roy. Soc., 53, 6 (1893).

amount corresponding to the ampere in computing Griffiths's *E*. Such an inaccuracy may have come about in two ways: either the electromagnetic methods for determining the *energy* of an ampere may have caused the original investigators of the ampere equivalent to overestimate the strength of their current, or else they may have used a form of voltameter which gave a smaller deposit of silver than the form used by Glazebrook in standardizing Griffiths's cells. This last supposition is the only one with which the voltameter is concerned, for it is clear that a *constant error* in the amount of silver, occurring both in the original comparison of the ampere value, as well as in the standardizing of Griffiths's cells, could have no effect, — the weight of silver would be eliminated from the result. The only safe mode of comparing results of this kind is to reduce all figures to the standard of some one form of silver voltameter, capable of giving constant values, as has been done above. Patterson and Guthe, in their otherwise valuable paper, do not seem to realize this fact, and only add to the confusion by appearing to suppose that the results with their plethoric voltameter are directly applicable to Griffiths's equivalent. (See line 4, p. 281 of their paper in the Physical Review, Vol. 7.)

This paper is by no means a final statement of the matters which it concerns. It is in the nature of a preliminary contribution, and we intend now to test more rigidly the accuracy of the "porous cup voltameter," as well as to study from a physico-chemical standpoint the cause of the anomalies which are rendered harmless by its use. Some light has already been obtained, and more seems not far off.

Summary.

In conclusion, a brief summary of the chief points treated in the paper may serve as an index to the more intricate details.

1. Metallic copper dissolves in cupric sulphate with the formation of cuprous sulphate, and unless acid is present cuprous oxide or hydroxide is formed by hydrolysis; in short, most of Foerster and Seidel's results are confirmed.

2. On the other hand, the saturation of the solution with cuprous salts is shown to cause too high results in the copper voltameter.

3. Vanni's method of correcting the copper voltameter by regulating the amount of acid present is shown to be unsound, although its results are not very erroneous.

4. Before the cupric solution is made so dilute that its solvent action

becomes negligible with a given current density, the deposition of hydrogen interferes with the exact determination of the electrochemical equivalent, even before hydrogen is actually evolved in bubbles. Hence the use of a small cathode is dangerous beyond a limit which depends upon the accuracy required. With small current density an approximate correction may be made for the area of the cathode.

5. Some possible causes of error in the silver voltameter are obviated by a simple device; and with the help of this apparatus the older methods are compared with one another. The danger of a fallacy in such a comparison is pointed out.

6. The electrochemical equivalent of silver appears to be about 0.0011172 gram per ampere per second.

7. The electrochemical equivalent of copper appears to be between 0.00032915 and 0.00032925 gram per ampere per second.

8. The discrepancy between the chemical atomic weights of copper and silver and their electrochemical equivalents is explained; hence Faraday's law is verified with two cathions more precisely than before. Conversely, assuming Faraday's law to hold rigidly, and the value 63.60 to represent the true atomic weight of copper, the agreement furnishes evidence of the accuracy of the new method.

Harvard University, Cambridge, Mass.,
October 14, 1899.

PUBLICATIONS

OF THE

AMERICAN ACADEMY OF ARTS AND SCIENCES.

MEMOIRS. Old Series, Vols. I.–IV.; New Series, Vols. I.–XII. 16 volumes, $10 each. Half volumes, $5 each. 25% discount to booksellers; 50% to members.

Vol. X.	Part II. *bis*	$1.75
" XI.	" I.	2.00
" XI.	" II. No. I.	3.00
" XI.	" III. " II.–III.	1.00
" XI.	" IV. " IV.	1.00
" XI.	" IV. " V.	.75
" XI.	" V. " VI.	.25
" XI.	" VI. " VII.	2.00
" XII.	No. I.	1.50
" XII.	" II.	2.00
" XII.	" III.	6.00
" XII.	" IV.	1.25

PROCEEDINGS. Vols. I.–XXXIV., $5 each. 25% discount to booksellers; 50% discount to members.

Complete sets of the Memoirs. 15 vols., for $112.50, to members, $60; of the Proceedings, 34 vols. for $129, to members, $68.

Proceedings of the American Academy of Arts and Sciences.

VOL. XXXV. No. 9. — DECEMBER, 1899.

CONTRIBUTIONS FROM THE CRYPTOGAMIC LABORATORY OF HARVARD UNIVERSITY. — XLI.

PRELIMINARY DIAGNOSES OF NEW SPECIES OF LABOULBENIACEÆ. — I.

BY ROLAND THAXTER.

CONTRIBUTIONS FROM THE CRYPTOGAMIC LABORATORY OF HARVARD UNIVERSITY. — XLI.

PRELIMINARY DIAGNOSES OF NEW SPECIES OF LABOULBENIACEÆ. — I.

By Roland Thaxter.

Received November 8, 1899. Presented November 8, 1899.

Since the publication by the Academy of the writer's "Contribution toward a Monograph of the Laboulbeniaceæ," * a large amount of material of the group has been accumulated, the greater portion of which has been derived from an examination of the entomological collections at the Jardin des Plantes in Paris, the South Kensington Museum of Natural History in London, the Hope Museum in Oxford, the collection of Italian Carabidæ in the Museo di Storia Naturale at Florence, and the National Museum at Washington. It is the writer's intention to publish as soon as practicable a Supplement to the Monograph just mentioned, including figures of all the species; but although a portion of the illustrations are already finished, it will be impossible to complete them without considerable delay, and it has therefore seemed advisable to publish preliminary diagnoses of the new species of the genus Laboulbenia, which will be followed shortly by a second paper, including such new forms as belong to other genera.

The writer desires in this connection to express his great obligations to the gentlemen in charge of the collections mentioned for the courtesies extended to him, due acknowledgment of which will be made in connection with the Supplement already referred to. It should be mentioned also that a set of duplicate preparations has been prepared and will be deposited at Paris, London, and Oxford, so that a majority of the new forms, as well as many others, will be accessible to European students of the group.

In the following descriptions no comparison of the forms has been attempted in the absence of figures which might render such comparison

* Memoirs, Vol. XII. No. 3.

intelligible. The very large mass of material obtained naturally contains many of the species previously reported, illustrating more fully than was formerly possible the geographical distribution, variation, and hosts of many of the species, notes concerning which are likewise reserved for a more extended paper. The numbers referred to apply to the specimens examined, which in the Hope and British Museum collections were labelled if found to be infested. A portion of the specimens examined at Paris were also labelled, but unfortunately this was not done in all cases.

Laboulbenia Acrogenis nov. sp.

Perithecium rather slender, free except at its base, pale yellowish or straw-colored, becoming yellowish brown, tapering to the neck-like rather slender often almost clavate apex, the lip-cells hyaline, well distinguished, the pore obliquely external: below more or less deeply suffused with smoky brown, especially the outer half, the posterior (outer) subterminal wall-cells very often becoming deeply suffused with smoky brown. Receptacle rather short, becoming slightly suffused with yellowish brown, normal in form, sometimes slightly inflated between cells I and II. Outer appendage consisting of a large rounded basal cell bearing four to eight branches arranged antero-posteriorly in a more or less definitely double row, their insertions forming a continuous deeply blackened area, their cells inflated, with blackened septa, successively once to three times branched antero-posteriorly. The inner appendage consisting of a much smaller basal cell producing from one to two branches similar to those of the outer, one on either side. The antheridia solitary or from two to four, borne rather regularly on short branchlets. Perithecium 90–175 × 28–35 μ. Antheridia 14 μ long. Total length to tip of the perithecium 190–360 μ. Appendages 85–100 μ. Spores about 40 μ.

On *Acrogenys hirsuta* MacLeary, Brit. Mus. Nos. 668 and 528, "Australia" and Union Reefs, Australia. Occurring on the inferior posterior margin of the prothorax and the adjacent portions of the thorax.

Laboulbenia adunca nov. sp.

Perithecium long and slender, straight or nearly so, the outer half clear dark translucent brown, the inner pale olivaceous, wholly free, a very short narrow hyaline neck formed by the basal wall-cells; the tip well distinguished, wholly blackish below or especially on the inner

side, the inner lips black-margined, curved outward over the outer lips in a characteristic hook-like fashion. Receptacle uniform dirty olivaceous, cell I paler, the cells about it faintly punctate. Insertion-cell black, broad, indistinguishable from the blackened basal portions of the basal cells of the appendages. Outer appendage consisting of a large nearly triangular basal cell, becoming wholly blackened except its upper margin and surmounted by a series of usually six superposed hyaline cells curved toward the perithecium, each cell producing externally a single simple branch consisting of a basal portion made up of two roundish short cells constricted at the dark septa and a distal portion six or more times as long, tapering, hyaline or tinged with brownish; the inner appendage consisting of a basal cell wholly or almost wholly black, giving rise on either side to a short series of cells, usually three or four, similar to that of the outer appendage and similarly branched. Perithecia 225–245 × 40 μ (including neck, which is about 18 μ long). Total length to tip of perithecium, average 450 μ; to insertion-cell 200 μ, greatest width 50 μ. Appendages 150 μ.

On *Galerita unicolor* Dej., Brit. Mus. No. 516, Amazon River. Inferior surface of prothorax.

Laboulbenia Aerogenidii nov. sp.

Form short and stout. Perithecium suffused with smoky brown, translucent, becoming distally rather abruptly subhyaline, contrasting with the abruptly differentiated tip; the latter black-brown, opaque or nearly so below, the lip-cells usually symmetrical, rounded, spreading broadly and rather abruptly, the lip-edges translucent; sometimes asymmetrical with the inner lip-cells only prominent and the pore external: the wall-cells with a slight spiral twist. Receptacle hyaline below, becoming more or less tinged with smoky brown above, especially cells III and IV and the region immediately below the perithecium; the suffused parts indistinctly punctate. Appendages consisting of two basal cells; the inner producing two short branches on either side, which usually bear a rather compact cluster of antheridia; the outer giving rise to from two to four branches placed antero-posteriorly with more or less regularity, the outer for the most part soon broken and deeply blackened, the rest especially the outermost more or less suffused with brown, commonly twice branched, above the basal and subbasal cells, elongate though for the most part broken. Total length to tip of perithecium 200–220 μ. Appendages 200–250 μ. Perithecium 110–120 × 35–45 μ, the apex reaching a width of 35 μ.

On *Aerogenidion Bedeli* Tsch., Mon-Pin (China?), Paris, No. 179. Along the margins of the elytra.

Laboulbenia Anaplogenii nov. sp.

Perithecium nearly hyaline or pale yellowish, becoming tinged with pale amber-brown, stout, free except at its base, the outer margin mostly straight, the inner convex; the tip rather small and abruptly distinguished, blackish except the hyaline lip-margins. Receptacle concolorous with the perithecium, rather short and stout, cell V relatively large, cell IV divided by transverse septa into from two to several superposed cells, usually extending upward beyond the insertion-cell, thus forming a blunt outgrowth external to it. Basal cells of the appendages nearly equal, each producing as a rule two similar branches antero-posteriorly, once or twice branched in the same plane, the branchlets rather elongate and slender, concolorous with the receptacle. Spores $50 \times 4.5\,\mu$. Total length to tip of perithecium 300–350 μ, to insertion-cell 200–240 μ, greatest width 50–70 μ. Appendages, longest 600 μ, average 300 μ.

On *Anaplogenius circumcinctus* Moh., Brit. Mus. Nos. 622 and 665, China. Also immature material of apparently the same species on an undetermined Carabid, Paris Museum, No. 4, from Madagascar. On the elytra.

Laboulbenia Anchonoderi nov. sp.

Pale amber-yellow, perithecium slightly darker, about two thirds free, the inner lip-cells suffused below with blackish brown, an external prominence involves the upper portion of the subbasal and lower portions of the subterminal wall-cells, forming, in the specimens from *A. subæneus*, an abruptly defined hunch. Receptacle normal, the basal and subbasal cells usually slender and somewhat darker, the subbasal more distinctly marked with fine transverse striations which are less distinct on the cells above it. Appendages concolorous, the outer simple (always?), the inner consisting of a basal cell similar to that of the outer, about twice as long as broad, giving rise on either side to a single branch which may be once branched above its basal cell; all the branches somewhat flexed. Insertion-cell red-brown or purplish, more or less oblique through the upgrowth of cell V. Spores about 45–48 μ. Perithecia (larger) $185 \times 48\,\mu$, average $125 \times 48\,\mu$. Total length to tip of perithecium 275–500 μ (longest 535 μ). Appendages about 200 μ.

On *Anchonoderus subæneus* Reiche, San Felix, Panama, and *A. binotatus* Reiche, Guatemala City, Brit. Mus. (Biologia coll.), Nos. 706 and 707. On the elytra.

Laboulbenia angularis nov. sp.

Perithecium wholly free, symmetrically inflated, straight, evenly suffused with smoky brown except the very short narrow hyaline neck-like base; the tip well differentiated, black, distally hyaline, the whole perithecium inserted nearly at right angles to the axis of the receptacle. Receptacle amber-yellow or amber-brown, the basal cell tinged with smoky brown, cell II abruptly broader and long, all the cells except cell I more or less conspicuously marked by short transverse striæ, cell V bulging on the inner side and carrying the black insertion-cell out free from the neck of the perithecium. Outer appendage consisting of an erect series of about six obliquely superposed cells, the lower becoming nearly opaque, the basal one larger and darker, opaque externally and below; each cell bearing externally a single simple branch, the branches consisting of a basal portion of three short cells prominently constricted at the blackish septa, and a terminal portion (broken in the types): the inner appendage consisting of a basal cell which gives rise to a series of superposed cells on either side, like that of the outer appendage and similarly branched, one of the series in the types much shorter than the other (two and four celled), the branches all erect, closely apposed, more or less suffused with brownish. Perithecia 280 × 45–55 μ. Total length to tip of perithecium 680 μ; to insertion-cell 420 μ; greatest width 75 μ. Appendages (broken) 55 μ.

On *Galerita unicolor* Dej., Brit. Mus. No. 516, Amazon River. Inferior surface of prothorax.

Laboulbenia anomala nov. sp.

Perithecia nearly symmetrical, free except at the base, tapering distally, the tip somewhat lighter, subtruncate with one (or more?) of the lip-edges modified to form a prominent large somewhat irregular blackish brown median projection which causes the tip to appear notched on the inner side. Receptacle dirty olive-brown, finely punctuate, the whole curved almost to a horseshoe form: cells I and II about equal in length and diameter, the base of the perithecium opposite cell III, insertion-cell unmodified external subtriangular, cell V similar to it, about twice as large and occupying a corresponding position on the inner side; the two together with the terminal portion of cell IV, on either side of which they lie, form the free broadly clavate terminal portion of the receptacle above the narrower and also wholly free basal half or more of cell IV. Basal cells of appendages not distinguishable, giving rise to a number of prominences (about twelve) each forming the base of a branch, the branches

simple or rarely branched, hyaline, of two kinds, the one with long slightly inflated basal cells, the other closely septate, intermediate forms occurring in which the septa are more remote; all the septa brownish purple. Perithecia $140 \times 40\,\mu$. Total length to tip of perithecium about $450\,\mu$; to tip of free end of receptacle $450\,\mu$. Appendages 140–160 μ.

On *Orectogyrus suturalis* Reg., Paris, No. 102, Zambesi River, Africa; on *O. glaucus* Klug., Brit. Mus. No. 465, Coast Castle, Egypt. On elytra.

Laboulbenia aquatica nov. sp.

Perithecium free nearly to its base, rather short and stout becoming dark olive-brown, the wall-cells very slightly twisted, the blackened tip well differentiated; nearly symmetrical, subtruncate, the lip-edges hyaline, the lip "valves" prominent. Receptacle rather short and distally broad, olivaceous, lighter below. Insertion-cell unmodified, external, about as large as and nearly symmetrical with cell V, the two lying side by side above cell IV. The appendages consisting of an outer basal cell from which is formed a primary dark brown terminal prominence bearing several small branches distally, while about its base externally and often on only one side several secondary unmodified prominences arise, each producing usually a single terminal branch. The inner basal cell moderately distinct, at first simple, later apparently divided or lobed and bearing several branches. All the branches hyaline, constricted at the lower (four to about six) dark, mostly oblique septa; the distal portion slender, elongate, subrigid, tapering, without constrictions or colored septa, the basal segments bearing numerous typical flask-shaped antheridia. Spores $70 \times 4.5\,\mu$. Perithecia, average $100 \times 38\,\mu$. Total length to tip of perithecium average $220\,\mu$; to insertion-cell $150\,\mu$; greatest width $30\,\mu$. Appendages, longest $175\,\mu$.

On *Gyretes*? sp., Paris Museum, No. 106, Venezuela. On elytra.

Laboulbenia aristata nov. sp.

Perithecium less than one half free from the receptacle, pale amber-yellow, straight and symmetrical or nearly so, the tip well distinguished, symmetrical, blackish, the lip-cells symmetrically rounded and protruding slightly on either side, their distal margins straight and horizontal or nearly so. Receptacle concolorous with the perithecium, cell I tinged with brown, a brownish shade below the base of the perithecium, cell IV bulging distally where it is rather faintly suffused with blackish. Outer

appendage simple, the basal cell more than twice as long as it is broad, the two cells above it abruptly narrower and equal; two or three of the cells above these broader with thicker walls, the rest of the appendage tapering; the whole rigid, straight, erect or bent toward the tip of the perithecium, a part of which it may overlap; inner appendage consisting of a small basal cell bearing a very short one or two celled branch on either side. Perithecia 95–110 × 30 μ. Total length to tip of perithecium 240–260 μ; to insertion-cell 185–200 μ; greatest width 60 μ. Appendages 260–330 μ.

On Carabid (? near *Pericallus*), Hope Collection, No. 322, Bouro, East Indies (A. R. Wallace). On superior margin of prothorax.

Laboulbenia Asiatica nov. sp.

Perithecium and receptacle as in typical forms of *L. elongata*, more or less suffused with dirty brownish yellow, the perithecium somewhat smoky brown above the basal wall-cells. Outer appendage consisting of a large subtriangular hyaline basal cell, which gives rise from a deeply blackened area of insertion to an antero-posterior series of short stout cells, themselves outwardly blackened and giving rise to from one to three branchlets also placed antero-posteriorly and themselves mostly once branched in a similar plane, the ultimate branchlets rather long and remotely septate, the basal septa only blackened. The inner appendage consists of a smaller basal cell which gives rise on either side to a series of from two to three branches arranged antero-posteriorly on a blackened insertion as in the outer appendage, the branches once or twice branched, the branchlets shorter than those of the outer appendage. Perithecium 140 × 45 μ. Total length to tip of perithecium 400–500 μ. Appendages (longest) 400 μ.

On *Casnonia* sp., Asia, Paris, No. 139. Elytra.

Laboulbenia Assamensis nov. sp.

Perithecium mostly long and slender, free except at its very base, evenly suffused with dark slightly reddish brown, paler distally, tapering very slightly and gradually to the not abruptly differentiated tip which is somewhat rounded and slightly bent inward, suffused with blackish brown; the left lateral lip-cell prolonged to form a blackish blunt-tipped prominent outgrowth which is either erect or bent slightly outward or inward. Receptacle dirty brownish yellow with fine rather indistinct transverse striations, cell V very small, often hardly visible against the perithecium.

Appendages concolorous with the receptacle, the outer simple, straight, rigid, mostly somewhat divergent; the inner consisting of a basal cell often as large as that of the outer, and giving rise on either side distally to a branch similar to the outer appendage which bears several lateral antheridia near the base. Perithecium (including outgrowth 18 μ) 185–190 × 33–37 μ. Total length to tip of perithecium 375–450 μ; to insertion-cell 185–300 μ; greatest width about 48 μ. Appendages, 150 μ.

On *Catascopus?* sp., Brit. Mus. No. 663, Assam, India. Inferior surface.

Laboulbenia barbata nov. sp.

Perithecium large, pale yellowish or brownish becoming slightly tinged with amber-brown, often symmetrically inflated and tapering gradually to the tip, which is brownish below becoming black on the inner side, the lips subhyaline, turned slightly outward. Receptacle concolorous with the perithecium, normal except that cell V is greatly enlarged and extends upward covering nearly one half of the inner margin of the perithecium, bulging strongly outward and carrying out the insertion-cell which is thus made lateral in position. Insertion-cell externally concave or indented. The outer appendage consisting of a small roundish basal cell giving rise to two, rarely more, branches antero-posteriorly, which are usually once branched near the base, the branchlets very elongate, slender, attenuated, curved outward and downward: the inner appendage consisting of a similar basal cell from which arise usually two branches, one on either side, similar to those of the outer appendage, the whole forming a hanging beard-like tuft. Perithecia 190–200 × 55–60 μ. Total length to tip of perithecium, average 400 μ; to insertion-cell, average 190–200 μ. Appendages, longest 450–650 μ. Spores 100 × 6 μ.

On *Morio Georgii* Pal., Brit. Mus. No. 690 (Biologia Collection), El Zambador, Mexico; on *M. simplex*, Dej., Brit. Mus. No. 581, Cayenne; on *M. monilicornis*, Latr., Hope Collection, No. 289, "North America." On the elytra.

Laboulbenia bicornis nov. sp.

Perithecium wholly free, dark brown tinged with olive becoming opaque, lighter at the base; very elongate, nearly straight, slightly and gradually inflated from the neck-like base to about the middle, thence tapering very slightly to the tip, which is distinctly though not abruptly differentiated: the two inner lip-cells symmetrical each terminating in a small rounded prominence which bears a second smaller rounded terminal

prominence; from the base of the lower prominence a long slender brown or olive-brown horn-like process grows downward, inward, and upward, the two symmetrical and similar and resembling the horns of an ox; though formed from the *inner* lip-cells, a slight twist in the wall-cells usually makes them appear lateral or even external. The two outer lip-cells grow beyond the inner and are closely united forming a large bluntly pointed nose-like projection, its inner margin slightly convex while externally it is nearly straight and slightly oblique. Receptacle short and stout, evenly dark olive-brown; cell I short, slender, cell II abruptly larger, broad and short. The basal cells of the appendages opaque and indistinguishable, giving rise as in allied aquatic species to cladophorous prominences, the branches once or twice branched, hyaline, the lower three or four septa dark, the cells between them slightly inflated, the distal portion elongate, cylindrical, thin-walled, blunt-tipped, without dark septa, the whole forming a dense tuft. Spores 125–140 × 7–8 μ. Perithecia 340–750 × 60–75 μ. Total length to tip of perithecium, longest 1150 μ; to insertion-cell 340–400 μ; greatest width 120–130 μ.

On *Dineutes aereus* Klug., Brit. Mus. No. 461, Hadramaut, Arabia; on *Dineutes* sp., Brit. Mus. No. 463, Ambaca, Angola, W. Africa. On abdomen, elytra, thorax, and head.

Laboulbenia bidentata nov. sp.

Wholly suffused with pale dirty brown. Perithecium rather darker, free except at its base, somewhat inflated below, tapering symmetrically from the extremity of the basal wall-cells to the rather narrow apex; the two inner lip-cells suffused with blackish brown and projecting beyond the others to form two blunt prominences, their tips hyaline, contrasting. Receptacle rather short and stout, uniform pale dirty brown, inconspicuously flecked with minute somewhat darker points, the lower part of the small basal cell mostly hyaline. Outer appendage consisting of a basal cell several times as large as that of the inner, bearing a single branch, the basal cell of which is somewhat rounded and gives rise distally to an outer and an inner branchlet, each commonly once branched, the outer deeply blackened at the base (usually broken): the inner appendage consisting of a basal cell which bears a branch on either side which may be twice branched, bearing solitary antheridia laterally. Spores 50 × 4 μ. Perithecia 115–130 × 45 μ. Total length to tip of perithecium 220–270 μ; to insertion-cell 135–150 μ. Greatest breadth 70 μ.

On *Homothis* sp., St. George's Sound, Australia, Hope Coll., No. 309. On elytra.

Laboulbenia Brachionychi nov. sp.

Perithecium wholly free, rather deeply suffused with smoky or reddish brown, subclavate or almost symmetrically inflated, tapering from the middle to the nearly symmetrical, or externally slightly oblique blunt tip, the basal wall-cells contracted to form a long slender neck-like subhyaline stalk. Receptacle abnormally developed, cells I and II nearly equal, cells III and V forming a stalk which is deeply suffused with blackish brown especially externally, and rather coarsely punctate in the darker areas, of equal diameter throughout and quite free, except at its very base, from the rest of the receptacle: cell IV larger than cell III, cell V small and separated by an oblique septum; cell VII and the basal cells of the perithecium small. Outer appendage consisting of a basal cell deeply blackened externally, and bearing a long slender simple branch, distally hyaline, more or less suffused with smoky brown towards the base: the inner appendage consisting of a basal cell about half as long as that of the outer, producing a single branch on either side which may be once or twice branched, the antheridia borne usually in twos or threes on short branchlets near the base. Spore $110 \times 7\,\mu$. Perithecia exclusive of stalk, $270–340 \times 65\,\mu$; including stalk $340–430\,\mu$. Total length to tip of perithecium $650–800\,\mu$; to insertion-cell $400–500\,\mu$. Stalk-like portion of receptacle $138 \times 38\,\mu$. Appendages $400–470\,\mu$.

On *Brachionychus* sp., Nos. 99 and 822, Cochin China; on *Episcosoma laticollis*, No. 85, Cochin China; on *Episcosoma* sp., No. 86, Java. All in Paris Coll. Usually on inferior surface of thorax.

Laboulbenia Cafii nov. sp.

Perithecium almost wholly free, pale amber-colored or straw-yellow, transparent, stout, the tip blunt, with blackish basal suffusions, well distinguished, especially on the inner side. Receptacle short and stout, pale amber-colored, normal in form. Insertion-cell broad, often not deeply blackened. The appendages consisting of an outer and an inner series of from four to six superposed cells which, through a twist of the insertion-cell, become lateral instead of antero-posterior in position; each cell of these series produces externally a single simple short branch usually three-celled, the two lower cells short and inflated, the upper longer tapering to a blunt apex. Perithecia $140–165 \times 60–70\,\mu$. Total length to tip of perithecium $310–350\,\mu$, to insertion-cell about $170\,\mu$. Appendages, longest $85\,\mu$.

On *Cafius seminitens* Horn, and *C. canescens* Mann, U. S. National Museum, Los Angeles, California. On *C. sericeus* Holme, Brit. Mus. No. 437, Great Britain. On *Cafius* sp., Brit. Mus. No. 425, "Europe," No. 395, Hong Kong; *C. bisulcatus* Sol., Chili. On elytra and legs.

Laboulbenia celestialis nov. sp.

Perithecia almost wholly free, rather deeply suffused with dark reddish brown except the almost hyaline basal wall-cells; tapering slightly to the well distinguished rather large tip, which is turned slightly outward, the lip-cells blackened except around the pore. Receptacle uniformly pale dirty brown, rather short and stout, somewhat abruptly expanded below the perithecium; cell IV broader than insertion-cell. Outer appendage consisting of a somewhat rounded basal cell deep brown externally and bearing usually two branches placed antero-posteriorly, the basal cell of the outer nearly round, deep brown externally and bearing two branches placed antero-posteriorly which are very long and slender, remotely septate and more or less suffused with dirty brown: the inner appendage consisting of a smaller basal cell producing a branch on either side, the basal cells of which are short with suffused septa and bear solitary antheridia or short sterile branches which are blunt and shorter than the perithecium. Perithecia 110 × 35 μ. Total length to tip of perithecium 280 μ; to insertion-cell 156 μ. Greatest width 55–60 μ. Appendages (longest) 400 μ.

On *Drypta lineola* Dej., Brit. Mus. No. 507, China. Elytra.

Laboulbenia ceratophora nov. sp.

Perithecium wholly free, borne on a short nearly hyaline stalk, tinged not deeply with brown, for the most part nearly straight, rather slender, hardly inflated, the outer margin usually slightly concave; tapering slightly and rather abruptly to the peculiarly modified tip; the tip black except externally immediately about the pore, a large blunt tooth-like prominence projecting inward the upper surface of which is nearly horizontal while it is continued upward and outward into a longer more slender horn-like bluntly tipped outgrowth, the lower or external margin of which may be partly hyaline. Receptacle yellowish tinged with brown subdistally, rather narrow distally, cell IV small and hardly longer than cell V. Insertion-cell opposite the distal extremity of the short perithecial stalk. The basal cell of the outer appendage longer and narrower than that of the inner, becoming concolorous with

the insertion-cell bearing a single branch of usually three cells more or less deeply tinged with brown, each of which may give rise distally on the inner side to a short simple branchlet; the inner appendage consists of a basal cell shorter and broader, which usually bears distally on either side a branch, the basal cell of which usually bears distally two erect simple branchlets, one of them sometimes replaced by a single large long-necked brown antheridium. Perithecia, including the stalk (17 μ), 150–155 $\times$ 30 μ. Total length to tip of perithecium 290–310 μ; to insertion-cell 150 μ; greatest width 35 μ. Appendages, longer 200 μ.

On *Serrimargo guttiger* Schaum, Hope Collection, No. 300, Sumatra; on *Miscelus Javanus* Klug., Hope Collection, No. 303, Java; on *Miscelus* sp., New Guinea, Paris Museum, No. 114. On elytra and inferior surface of the prothorax.

Laboulbenia Ceylonensis nov. sp.

Perithecium wholly free, suffused with smoky brown, relatively short and small, straight, slightly inflated, somewhat abruptly contracted distally to form the unusually large broad tip, the distal half of which is hyaline, distinguished from the opaque black lower half by a clean cut line of demarcation: the basal cells forming a short stout hyaline neck narrower than the body of the perithecium. Receptacle elongate, of nearly the same diameter throughout, the basal cell nearly hyaline, the cells above it more or less deeply suffused with smoky brown, cell V and the upper portion of cells IV and VII hyaline, the distal suffused portion obscurely punctate. Outer appendage consisting of a basal cell deeply blackened externally (the blackened area continuous with the black insertion-cell and involving also the external walls of the two cells immediately above it) producing from one to three branches arranged antero-posteriorly, which may be once or twice branched in a similar fashion, the branchlets long, slender, drooping, hyaline, some of the lower cells suffused with reddish brown: the inner appendage consisting of a basal cell about half as large as that of the outer, producing in the types a single branch which may be once branched as in the outer. Perithecium 105 $\times$ 32 μ. Total length to tip of perithecium 445 μ; to insertion-cell 320 μ. Greatest breadth 42 μ. Appendages 340 μ.

On *Hexagonia?*, Ceylon, Hope Coll. No. 288. On elytra.

Laboulbenia Chiriquensis nov. sp.

Perithecium yellowish brown, straight, the inner margin convex, the outer slightly concave, tapering distally to the broad short blackened tip,

which is bent abruptly inward almost at right angles. Receptacle yellowish brown, deeper in the region of cell III, the basal cell slightly curved, its upper half rather abruptly expanded; a more or less distinct bulge below the perithecium. Outer appendage usually simple, stout, the basal cell of the inner usually much smaller bearing a branch on either side usually once branched above the basal cell; all the branches stout and constricted at the lower septa. Spores $60 \times 4\,\mu$. Perithecium $100–125 \times 37\,\mu$. Total length to tip of perithecium $200–270\,\mu$; to insertion-cell $135–160\,\mu$. Greatest width $55\,\mu$.

On *Calleida scintillans* Bates, Brit. Mus. (Biologia Coll.), No. 735, Vale de Chiriqui, Panama. On margin of elytron.

Laboulbenia Clivinalis nov. sp.

Usually rather slender. Perithecium three fourths or more free, more or less deeply tinged with blackish olive-brown, distally curved slightly outward, the tip black with hyaline lip-edges. Receptacle wholly hyaline, or cells III and IV becoming more or less suffused with blackish brown, the suffused areas punctate: bulging distally below the perithecium. Insertion-cell well differentiated, black. Appendages consisting of an inner and an outer basal cell, which may remain simple or become longitudinally divided, sometimes also transversely or even obliquely: the outer basal cell hyaline, often several times as long as broad, its distal septum blackened; when simple, bearing a single branch, if divided, several; the basal cell of the outer branch usually rather short and somewhat suffused, commonly bearing two branchlets. The basal cell of the inner appendage usually smaller than that of the outer, sometimes equal, and like it simple or divided; when simple, bearing a branch on either side, or more if it is divided. All the branches of both appendages hyaline or nearly so, mostly once branched above their basal cells. Spores about $55 \times 4.5\,\mu$. Perithecia $120–150 \times 35–50\,\mu$. Total length to tip of perithecium $275–400\,\mu$; to insertion-cell $200–340\,\mu$. Appendages, longest $300–400\,\mu$.

On *Clivina collaris* Herbst, Hope Coll. No. 348, and Brit. Mus. No. 456, both from England. On *Clivina fossor* Linn., Hope Coll. Nos. 353, 275 and 475, England; No. 295, "Europe"; Florence Mus., Italy. Usually on elytra and superior prothòrax, but occurring elsewhere.

Laboulbenia coarctata nov. sp.

Perithecium short and stout, dark brown and opaque, its upper half free, its contour evenly rounded, the small papillate translucent tip turned

slightly inward and abruptly differentiated, the lips well defined. Receptacle dirty brown finely and obscurely punctate, of the typical form, lighter below, short, stout, cell I much narrowed below, cell II very broad, slightly inflated. Basal cells of appendages well developed bearing about eight erect short stout simple branches with broad basal constricted blackened septa, their rounded tips slightly exceeding the tip of the perithecium. Spores $70 \times 7\,\mu$. Perithecia $140–170 \times 62\,\mu$. Total length to tip of perithecium $325–400\,\mu$; to insertion-cell $250–300\,\mu$; greatest width $100\,\mu$.

On *Orectochilus?*, Hope Coll. Nos. 233 and 234; Brit. Mus. No. 466, Bengal, India. Along median depression of elytra.

Laboulbenia Colpodis nov. sp.

Perithecium wholly free, very large, uniform clear translucent brown, slightly inflated or the margins straight, the basal wall-cells forming a well marked hyaline neck as broad as the base of the ascigerous portion from which it is not abruptly distinguished; the tip rather narrow and well distinguished, darker, the distinct lip-edges hyaline or translucent. Receptacle very small, cell I hyaline or yellowish, the rest more or less deeply suffused with blackish brown becoming nearly opaque, especially cells III and IV, which lie side by side and are about equal in size, cell III forming a rounded prominence just below the outer edge of the insertion-cell, cell V triangular, about as large as cells III and V combined. Insertion-cell not at first deeply blackened, but becoming indistinguishable in the general blackish brown suffusion of the adjacent cells. Outer appendage consisting of a nearly erect series of obliquely superposed small cells (sometimes as many as thirteen) at first hyaline, the basal cell and sometimes several of the cells above it becoming deeply suffused, which produce externally a single simple branch curved upward, its basal portion consisting of two cells, sometimes three, longer than broad and more or less deeply suffused with brown, constricted at the dark septa; its distal portion elongate, reaching nearly to the tip of the perithecium, strongly tapering hyaline except at its base where it is involved by the brown suffusion of the basal part; the inner appendage consisting of a basal cell surmounted on either side by a series of cells similar to that of the outer appendage, but fewer in number, similarly branched except that the two or three lowest cells of each series bear single large stout straight brown antheridia, the basal cells of the series, as in the outer appendage, becoming suffused with blackish brown. Perithecia $190–220 \times 40–45\,\mu$. Total length to tip of perithecium 300–

375 μ; to insertion-cell 75–80 μ; greatest width 55 μ. Appendages, longest 220 μ.

On *Colpodes Chiriquinus* Bates, Brit. Mus. No. 735 (Biologia Coll.), Vale de Chiriqui, Panama. On elytra.

Laboulbenia constricta nov. sp.

Perithecium more than one half free; short, stout, inflated, somewhat olive-brown, the tip not differentiated, one of the lip-edges becoming modified to form a flattish or roundish brown prominence which lies usually in a median position between two rather ill defined prominences on either side of it. Receptacle usually with a double curvature, its basal cell very large, somewhat inflated distally, the base and posterior margin paler, cell II shorter, suffused below, strongly constricted distally, the constricted portion paler or hyaline: the distal portion of the receptacle short, deeply suffused, bulging strongly anteriorly below the insertion of the appendages. Insertion-cell not blackened, the appendages arising much as in *L. Orectochili* and *L. strangulata*, the branches hyaline, the basal portion closely septate, simple, without persistent blackened basal portions. Spores 70 × 6 μ. Perithecia, average 130 × 60 μ. Total length to tip of perithecium, average 400 μ; to insertion-cell 340 μ. Appendages 70 μ (or more ?).

On *Orectogyrus glaucus* Klug., Brit. Mus. No. 465, Coast Castle, Egypt. On elytra.

Laboulbenia Copteæ nov. sp.

Very slender. Perithecium free except the base, nearly straight, curved outward slightly at the tip, which is blackish with hyaline lip-edges; dull translucent olive-brown, concolorous with the receptacle, or with the basal wall-cells nearly hyaline. Receptacle slender, bulging slightly at the base of the perithecium, cell II narrower distally than cell I, the base of which is hyaline. Outer appendage consisting of a basal cell several times as long as broad, hyaline, usually curved strongly outward, constricted distally where the septum is suffused with dark brown below the single straight branch, which is more slender, elongate, tapering, hyaline, simple or once branched above its basal cell. Inner appendage consisting of a small basal cell bearing a short branch on either side, simple or once branched, usually not longer than the perithecium. Perithecium 120–140 × 35 μ. Total length to tip of perithecium 340–470 μ; to insertion-cell 220–300 μ. Appendages (longest) 400 μ.

On *Coptea armata* Lup., Brit. Mus. No. 595, Santarem, Amazon River, Brazil. On elytra and superior prothorax.

Laboulbenia corethropsis nov. sp.

Perithecium relatively large, translucent brown or yellowish brown, generally larger distally through a subterminal external bulge, the tip moderately well differentiated, often bent rather abruptly inward, wholly blackish brown or hyaline in the median line, the inner lip-cells smaller and usually more prominent than the outer, sometimes overlapping them, the whole perithecium free from the receptacle. Receptacle short and rather stout, cells II–IV becoming externally blackish brown, the rest concolorous with the perithecium; cells III and IV rather prominent. Outer appendage wholly opaque, its successive cells indistinguishable as are the basal and insertion-cells, consisting of a blackened axis erect or bent outward, from the inner side of which arise several more or less blackened branches, the basal portion of the appendage only, as a rule, remaining. The inner appendage, consisting of a basal cell which is indistinguishable from the insertion-cell, being quite opaque, producing a branch on either side, the axis of the branches erect, becoming blackened and opaque, except the inner margins of the distal cells, bearing externally from six to ten or even more branchlets which are more or less deeply suffused. The general habit suggesting a species of *Corethromyces*. Perithecium 130–150 × 30–33 μ. Total length to tip of perithecium 190–240 μ; to insertion-cell 90–130 μ. Greatest width 40–50 μ. Appendages, longest (broken) 185 μ.

On *Miscelus Javanus* Klug., Hope Collection, No. 304, Java; on *Miscelus* sp., Paris Museum, No. 114, New Guinea. On inferior surface of abdomen, and on elytra.

Laboulbenia corrugata nov. sp.

Perithecium rather small, irregular, free from the receptacle except at the base, blackish brown, darker and almost opaque below, a rounded distal elevation extending completely round the perithecium, broader externally, forming a nearly opaque broad collar above which the tip is very abruptly distinguished; the latter subhyaline basally, a dark median external and internal suffusion, the lips translucent, faintly brownish, the two outer rounded and curved inward between the two inner, which form two free slightly unequal divergent blunt-pointed projections. Receptacle rather long and slender, pale brownish yellow with deeper

brown suffusions about the distal region of cell I and the basal region of cell II; the basal cells of the perithecium opaque and cell IV and V more deeply suffused; a series of prominent blackish brown tuberculate ridges extend more than half way across the receptacle from the anterior margin, beginning below the insertion cell and present as far as the base of cell II; cell IV bulging distally outside the insertion-cell. Outer appendage simple, erect, tapering, yellowish, perhaps once branched above the basal cell; inner appendage consisting of a smaller basal cell with a similar and shorter branch on either side. Perithecia 120 × 37–40 μ. Total length to tip of perithecium 340 μ; to insertion-cell 200 μ; greatest width 60 μ. Appendages 185 μ.

On *Serrimargo guttiger* Schaum., Hope Collection, No. 300, Sarawak, Borneo. On base of elytra.

Laboulbenia Cubensis nov. sp.

Perithecium short and stout, free except at the base, slightly curved toward the appendages, blackish olive, the lip-cells prominent but flattened backward and outward. Receptacle elongate, cells I and II dirty olive, cell III hyaline, long, contrasting with cells IV and V, which, together with the basal cells of the perithecium, are deeply suffused with blackish olive; cell VI as long as cell III and lying beside it, becoming tinged with dirty olive; basal cells of appendages dark olive, indistinguishable, producing concolorous prominences which give rise to a number of hyaline branches, the basal cells of which are large, swollen distally, and bear numerous terminal and subterminal branchlets externally; the branchlets once or twice branched, the septa olive. Perithecia 155–190 × 75–85 μ. Total length to tip of perithecium 480–800 μ. Appendages, longest 140 μ.

On *Dineutes longimanus* Oliv., Paris Museum, No. 101, Cuba. On tip of abdomen.

Laboulbenia dactylophora nov. sp.

Perithecium relatively small, its upper third only free from the receptacle, translucent smoky brown, the tip prominent, not abruptly differentiated, its upper half hyaline, black-tipped, symmetrical or irregularly sulcate, the lower half blackened. Receptacle very elongate, concolorous with the perithecium or paler, finely punctate, tapering below, its curved base hyaline, the basal cell expanding distally to the very broad upper septum, which forms the middle of a somewhat one-sided enlargement involving the adjacent extremities of cells I and II, cell II more dis-

tinctly punctate, very long, tapering very slightly nearly to its distal extremity, cell V producing two outgrowths, one on either side, erect, usually similar, brown, distally somewhat enlarged, the rounded tips often bent slightly outward, extending to or beyond the tip of the perithecium. Appendages consisting of two (or more?) basal cells from which several protrusions arise bearing groups of branches which are several times branched, forming a dense tuft not as long as the outgrowths from cell V, the lower septa brown or blackish, between the short cells. Perithecia 170–190 × 48–50 μ. Total length to tip of perithecium 750–880 μ; to insertion-cell 680–810 μ; cell II about 425 μ long. Outgrowths from cell V, 58 μ. Appendages 50 μ.

On *Orectogyrus specularis* Aube, Paris Museum, No. 100, Gold Coast, W. Africa. Margin of elytra.

Laboulbenia Darwinii nov. sp.

Perithecium hyaline becoming pale straw or amber-yellow, sometimes with a shade of brown, relatively small, its upper third or less free from the receptacle, the tip black, abruptly distinguished, the broad lip-edges translucent purplish brown. Receptacle relatively stout, indistinctly punctate with short lines or dots of darker yellowish color, cells II, III, and IV often unusually broad. Insertion-cell well developed, deep purplish brown or black. Outer appendage consisting of a short angular brownish basal cell, which bears an outer and an inner branch distally, the outer simple or once branched above its basal cell, the inner mostly simple; the outer branchlet mostly shorter, divergent, often deeply suffused with reddish brown, the rest less deeply colored, rigid, erect. The inner appendage consisting of a smaller basal cell which may produce a single branch, or two placed laterally or antero-posteriorly, short, simple with lateral antheridia or once branched. Perithecia 100 × 30–35 μ. Total length to tip of perithecium 150–275 μ; to insertion-cell 135–250 μ. Appendages, longest 200–250 μ.

On *Oezena parallela* W., Brit. Mus. No. 572, Rio de Janeiro (legit C. Darwin), on *Pachyteles* spp., Paris Mus. No. 137, South America, Hope Collection, Nos. 284 and 285, Brazil. Occurring usually at the base of the posterior legs.

Laboulbenia denticulata nov. sp.

Perithecium free, olivaceous with blackish shades below the paler tip, rather narrow, straight; the tip broad, one of the inner lip-cells forming a short brown conical terminal prominence which is straight or bent

toward the pore contrasting with the nearly colorless lip-edges below it. Receptacle pale brown or dirty olivaceous, elongate, normal. The insertion-cell nearly horizontal external to cell V, unmodified. The outer basal cell of the appendages giving rise to a single subconical brown prominence bearing branches terminally and externally and protruding beyond the inner basal cell, which is indistinguishable from the very numerous branches arising from it in all directions; all the branches hyaline, their basal cells bearing distally several branchlets which may again be branched, the four to eight lower septa dark. Perithecia, average $175 \times 44\,\mu$; the spine-like apex 10–12 μ. Total length to tip of perithecium 400–575 μ; to insertion-cell 275–400 μ; greatest width 55–70 μ. Appendages about 70 μ.

On *Dineutes* ?, Brit. Mus. No. 482, Adelaide River, Australia.

Laboulbenia Dineutis nov. sp.

Perithecium free except at the base, dark brown, the inner margin straight, the outer curved from the base to the tip, which is not well differentiated, the lip-cells inconspicuously modified to form an inner tooth-like brown prominence curved inward, and a median small brown rounded elevation, which is covered by an outer hyaline externally brown broad irregular elevation. Receptacle elongate or rather short, dark brown inconspicuously punctate. Appendages much as in *L. heterocheila*, the branchlets closely septate with dark septa near the base and (in unbroken specimens) with long hyaline aseptate or remotely septate terminations three to four times as long as the basal part. Measurements very variable. Perithecium, (Ceylon) $275 \times 72\,\mu$, (India) $140 \times 40\,\mu$. Total length to tip of perithecium, (Ceylon) 1 mm., (India) 400 μ, (Madagascar) 350 μ. Appendages, (Ceylon) 200 μ. Spores, (Ceylon) $75 \times 6\,\mu$.

On *Dineutes subspinosus* Klug., Paris, Nos. 33 and 34, Madagascar and Isle de France; Hope Collection, No. 236, no locality. On *Dineutes* spp., Hope Collection, Nos. 230, 231, 232, and 235, Bengal, "Pondich Guera," Asia, Ceylon, Mauritius. On *Dineutes*, Brit. Mus. No. 483, Nilgiri Hills, India. On margin of elytra and tip of abdomen.

Laboulbenia Dercyli nov. sp.

Perithecia free except at the base, short, stout, becoming tinged with brown, straight or the usually very broad tip turned slightly outward, the latter black, contrasting with the hyaline lip-edges. Receptacle elongate,

faintly and uniformly tinged with smoky brown, normal except that cell V is pushed up even beyond the hyaline unmodified insertion-cell which becomes thus external to it. Appendages recalling those of *L. variabilis*, typically consisting of an inner and an outer basal cell, the outer bearing a single oblique or nearly vertical more or less irregular row of branches arising antero-posteriorly; the inner basal cell bearing a similar row on either side, all the branches hyaline or yellowish brown, more or less copiously branched; the lower cells somewhat inflated, the septa blackened, often oblique, the basal cells of the branches bearing distally and externally from one to three obliquely superposed branchlets with blackened septa, which may branch again; the ultimate branchlets tapering slightly, the septa transverse and hyaline, usually cohering in an erect mass. A third group of branches similar to the rest sometimes arises between these and the perithecium, apparently from the distal portion of cell V. Perithecia 140–200 × 55–60 μ. Total length to tip of perithecium 475–875 μ; to insertion-cell 400–700 μ. Appendages, longest about 175 μ.

On *Dercylus tenebriosus* Laf. (= *Eurysoma tenebrioides*?), Hope Coll. No. 328, Para; Brit. Mus. No. 586, "S. America." Margin of right elytron.

Laboulbenia distincta nov. sp.

Perithecium short and broad, wholly united to the receptacle except the tip, clear dark brown, darker distally, the tip large, blackish, somewhat compressed, the lips translucent smoky brown, not prominently distinguished. Receptacle short and stout, the distal portion larger than the basal; cells I, II, and VI transparent yellowish, the rest smoky brown, marked by closely set fine transverse lines; cells III and IV relatively very large, subequal. Insertion-cell two thirds as broad as cells IV–V. Outer appendage consisting of three superposed flat cells, hyaline becoming dark brown, the two lower larger and nearly equal, the middle cell producing a single branch curving upward from its inner side, the third cell producing a similar branch from its inner side and a terminal branch which is deep brown curved outward and upward, slender, simple; the inner branches of the three cells all at first hyaline, mostly once branched, later developing a dark brown contrasting suffusion above their basal cells: the inner appendage consisting of a small basal cell producing a branch on either side the basal cell of which is larger than that of the appendage, and bears two branchlets basally suffused with brown like those of the outer appendage. Perithecia 130 × 50 μ. Total length to

tip of perithecium 275 μ; to insertion-cell 250 μ; greatest width 95 μ. Appendages, longest 235 μ.

On *Pericallus cæruleovirens*, Tat., Brit. Mus. No. 570, Singapore. On margin of elytra.

Laboulbenia drepanalis nov. sp.

Perithecium smoky olive, the inner half or less usually much paler, the upper three fourths free, falcate; the inner margin concave, the tip undifferentiated, the lip-edges forming a small hyaline rounded abruptly distinguished papilla. Receptacle rather short, concolorous with perithecium; cell I paler or hyaline with a basal blackish suffusion; cell V large, growing upward above the oblique insertion cell which is thus pushed out free from the perithecium together with the basal cells of the appendages. Insertion-cell small, unmodified. Basal cells of the appendages closely united, finally indistinguishable from one another, forming a prominent rounded outgrowth which gives rise to about six or eight branches, their dark basal septa of variable diameter only remaining, as a rule; the basal cells of the branches are distally inflated, and bear several branchlets externally and terminally, the basal cells of the branchlets mostly similar to those of the primary branches and similarly branched, the ultimate branchlets closely septate, the septa dark. Perithecia, Mexican specimens 100 × 40 μ, Amazon 140 × 35 μ. Total length to tip of perithecium, Mexican 210 μ, Amazon 275 μ; to insertion-cell, Mexican 130 μ, Amazon 140 μ.

On *Gyretes acutangulus*, Sharp, Brit. Mus. No. 771 (Biologia Coll.), Bugaba, Panama; on *Gyretes* sp., Brit. Mus. No. 477, Amazon. On mid-elytron.

Laboulbenia Egæ nov. sp.

Perithecium free or nearly so, slender, usually somewhat curved inward, becoming evenly suffused with pale olive-brown, the broad tip not differentiated from the body of the perithecium, the lip-cells more or less suffused with darker brown. Receptacle pale yellowish, often elongate, the basal cell short; cell II several times as long, becoming amber-brown with transverse striations; cells III and VI about equal, elongate. Insertion-cell not deeply blackened. Outer appendage consisting of a usually somewhat inflated basal cell with thick outer wall, bearing one or two branches placed close together antero-posteriorly, the branches simple or once branched, subhyaline; the inner appendage consisting of a basal cell half as large as that of the outer, bearing usually a single simple or

once divided branch on either side: the branches of both appendages subhyaline, mostly thin-walled, erect in a compact small tuft, tapering slightly, hardly exceeding the tip of the perithecium. Perithecium 190–225 × 34 μ. Total length to tip of perithecium 540–680 × 65 μ; to insertion-cell 375–470 μ. Appendages 175–200 μ.

On *Ega* sp., Paris Mus. No. 151, Acapulco, Mexico. On *Ega Sallei* Chev., Brit. Mus. No. 705, Biologia Coll., Paso Antonio and Champerico, Guatemala. On elytra.

Laboulbenia equatorialis nov. sp.

Perithecium free, hyaline becoming tinged with brown, slender and elongate; the basal wall-cells forming a well marked though not clearly differentiated hyaline stalk; a median and subterminal external prominence; the rather broad tip more or less deeply tinged with blackish brown, rather abruptly differentiated and bent outward, the lip-edges hyaline, the inner lip-cells prominent, more deeply suffused. Receptacle very long and slender, cell I short, cell II greatly elongated, cells III and VI about equal. Insertion-cell broad, deeply blackened. Outer appendage consisting of a somewhat rounded basal cell, which is hyaline externally, distally suffused with blackish brown, and bears two branches antero-posteriorly; the outer of which consists of a nearly isodiametric basal cell, opaque except its upper inner angle, from which arise two branches, the inner simple, becoming red-brown, its two lower cells inflated inward, the outer consisting of a small basal cell, opaque, except its inner upper hyaline angle and bearing two branches, an inner dark red-brown and slender, an outer curved outward and upward, more slender, deep red-brown, opaque toward the base, usually broken: the inner branch from the basal cell of the outer appendage consists of a basal cell like that of the outer branch, which bears distally two branches red-brown, about equal, the lower two cells inflated inward. The inner appendage consists of a slightly smaller basal cell bearing a branch on either side, the basal cell of each branch shorter, and giving rise typically to two branchlets from the basal cells of which the large, long, slender deep red-brown antheridia are produced in pairs. Perithecia 400–760 μ. Total length to tip of perithecium, average 550 μ; longest over 1 mm.; average breadth 50 μ. Appendages, longest 375 μ.

On *Casnonia* sp., Brit. Mus. No. 502, Amazon River. On upper surface of prothorax, at base of elytra and on legs.

Laboulbenia erecta nov. sp.

Perithecium pale yellowish brown, slightly and evenly rounded, united to the receptacle as far as its subterminal cells, the nearly symmetrical tip rather broad, often flattened distally, becoming deeply suffused with blackish, except the narrow translucent margins of the lips. Receptacle pale yellowish, cell I short and stout, distally suffused with blackish brown; cell VI very small, cell V free from the perithecium, sometimes lateral as in *L. paupercula*. Insertion-cell thick and black, sometimes carried forward opposite the apex of the perithecium through the elongation of cells IV and V. Outer appendage consisting of a large basal cell several times longer than broad, which may bear terminally one or two branches, the outer sometimes once branched, the branchlets very long, slender, tapering, hyaline or pale yellowish, more or less flexuous: the inner appendage sometimes laterally placed, usually single, simple, consisting of two or three short cells with one or two lateral antheridia and sometimes producing longer branchlets, the basal cell much smaller than that of the outer appendage. Perithecia 110–120 × 35–40 μ. Total length to tip of perithecium 200–275 μ; to insertion-cell 200–250 μ. Appendages, longest 675 μ.

On "*Colpodes agilis* Chd.," Jalapa, Mexico, Brit. Mus. (Biologia Coll.), No. 696; on *C. evanescens* Bates, U. S. National Museum, Biologia Coll., Mexico. Elytra.

Laboulbenia falcata nov. sp.

Perithecium free or nearly so, mostly very large, pale yellowish, the inner half or more suffused with smoky brown, darker toward the margin, the base more or less strongly curved so that the perithecium is directed outward nearly at right angles to the axis of the receptacle or even recurved, basally inflated along the inner margin, tapering gradually from about the lower third to the apex; the tip not differentiated from the body of the perithecium, the lip-cells with darker longitudinal brown shades. Receptacle short, straight or nearly so, the basal cell broad, sometimes slightly inflated, a slight constriction often present between cells II and III, all the remaining cells unusually small in proportion. Outer appendage consisting of a small rounded basal cell bearing a single branch separated from it by a blackened septum and consisting of a hyaline externally blackened basal cell bearing two branchlets; an outer (usually broken) externally blackened and bearing several vertical branchlets; an inner usually simple, hyaline or yellowish. Inner appendage consisting of a

basal cell similar to that of the outer or slightly smaller, producing a branch on either side, each usually once branched, all the branches pale yellowish with occasional brown suffusions, the longest not greatly exceeding the tip of the perithecium. Spores 35 × 3 μ. Perithecium 150–200 × 35–55 μ. Total length to tip of perithecium 275–380 μ; to insertion-cell 140–190 μ. Width 34–40 μ. Appendages 175–275 μ.

On *Casnonia* sp., Paris Mus. No. 116 *bis*, Bahia, Brazil. At base of elytra and on superior prothorax.

Laboulbenia fallax nov. sp.

Perithecium becoming dark dirty olive-brown, the tip blackened, bent outward, the lips hyaline. Receptacle becoming concolorous with the perithecium except the hyaline slender basal cell, the remaining cells usually short and stout except cell V, which extends up along the inner margin of the perithecium nearly to its tip, its inner margin continuing the curvature of the tip down to the insertion of the appendages, so that the perithecium seems at first sight twice its actual size. Insertion-cell unmodified, forming a slight rounded external prominence within which the basal cells of the appendages form an evenly curved base from which arises a single antero-posterior row of branches about twelve in number, their lower cells slightly inflated, hyaline with dark septa, usually twice branched; the ultimate branchlets above the third or fourth septum slender without dark septa, scarcely exceeding the tip of the perithecium. Perithecium 100–120 × 35–40 μ. Total length to tip of perithecium 190–325 μ; to insertion-cell 120–250 μ. Greatest width 85 μ. Appendages 50 μ. (The larger measurements are from the Amazon specimens.)

On *Gyretes acutangulus* Sharp, Brit. Mus. No. 771 (Biologia Coll.), Bugaba, Panama; on *Gyretes* sp., Brit. Mus. No. 477, Amazon River; on *Gyretes* sp., Hope Coll. No. 229, Rio de Janeiro. At tips of elytra.

Laboulbenia finitima nov. sp.

Perithecium one half to two thirds or more free, olivaceous brown, lighter distally, becoming wholly dark brown, straight or curved outward rarely inward; the tip broad, rounded, generally not well differentiated, blackish. Receptacle relatively small, the basal cell hyaline or yellowish, the rest concolorous with the perithecium; cells III–V lighter, cell VI extending down almost to cell I. Appendages brownish or pale olivaceous, the outer simple, its basal cell twice as long as broad, externally more deeply tinged with brown; the basal cell of the inner appendage

half as large, bearing a branch like the outer appendage on either side: all the branches erect, closely associated, and often bent terminally across the tip of the perithecium which they scarcely exceed. Perithecia, average 125 × 45 μ. Total length to tip of perithecium, average 240 μ; to insertion-cell 145–150 μ; greatest width 48–50 μ. Appendages 30 μ.

On *Pericallus guttatus* Chev., Paris Museum, No. 78, Brit. Mus. No. 571, Java; on *P. cæruleovirens* Tat., Brit. Mus. No. 570, Singapore. On the legs.

Laboulbenia fissa nov. sp.

Perithecium three fourths or more free, short and stout, slightly bent toward the appendages, dirty olive-brown becoming deeply suffused with blackish brown except distally just below the tip, which is abruptly distinguished, long, narrow, hyaline below its black distal portion, furcate, the inner fork formed by the upgrowth of one of the inner (right) lip-cells which grows outward and abruptly upward beside the deep black blunt-tipped projection formed by the other three which it may equal in length, though narrower and somewhat paler. Receptacle short, the basal cell largest, pale yellowish or hyaline, of about the same diameter throughout, broader than cell II, which is short, narrow, of equal diameter throughout, hyaline or yellowish at the very base, the rest opaque and indistinguishable from the remainder of the receptacle, which expands abruptly above, becoming opaque except the upper part of cell IV and cell V. Insertion-cell much narrower than cells IV–V. Outer appendage consisting of several superposed cells, which form a black opaque axis, usually broken off, curved outward, each cell producing a short hyaline or brown edged branchlet distally on the inner side; the inner appendage consists of a smaller basal cell, which gives rise on either side to a branch much like the outer appendage, its main axis less deeply blackened, curving outward on either side of the perithecium, the hyaline branchlets arising from its convex side mostly once branched. Perithecia, average 150 × 48 μ, including the tip, which is about 45 × 18–20 μ. Total length to tip of perithecium 290–300 μ; to insertion-cell 185 μ; greatest width 70 μ. Appendages about 110 μ.

On *Pericallus gutattus* Chev., Paris Museum, No. 78; Brit. Mus. No. 571; Hope Collection, No. 301, Java. On *P. flavoguttulus* Dej., E. Indies. On elytra.

Laboulbenia forficulata nov. sp.

Perithecium free, straight or somewhat curved, slightly inflated, brown except the basal wall-cells which form a mostly hyaline well developed narrow neck-like stalk less than one third as long as the ascigerous portion, the latter tapering rather abruptly at the tip, two of the lip-cells prolonged to form a pair of erect pointed hyaline symmetrical apposed outgrowths which resemble the tips of a pair of shears. Receptacle short, stout, subtriangular, cell I hyaline below, forming a short slender usually curved pedicel; the body of the receptacle suffused deeply below with blackish brown, the more deeply suffused portions coarsely punctate with darker spots. Appendages arising much as in *L. palmella*, the outer consisting of a basal cell from the blackened upper and outer margin of which arise usually three branches in an antero-posterior series, which are curved slightly outward and give rise from their convex side to secondary branches which in turn may bear branchlets in a similar fashion: of the primary branches the inmost is more copiously branched, the outmost being small, usually broken; all the branches black externally and brown on the inner margins, or wholly opaque, usually constricted on the inner side at the blackened septa, the terminal cells of some of the ultimate branchlets abruptly inflated at the base: the basal cell of the inner appendage gives rise to a branch on either side, the two divergent and very similar in character and mode of branching to those of the outer appendage. Perithecium exclusive of neck, 150–200 × 28–38 μ; the neck 35–50 μ long. Total length to tip of perithecium 300–450 μ; to insertion-cell 100–150 μ; greatest width 50–70 μ. Appendages 175–200 μ.

On *Thyreopterus striatus* Guer., Hope Collection, No. 302, Madagascar. On elytra.

Laboulbenia geniculata nov. sp.

Perithecium free, long and narrow, translucent olive-brown except the short somewhat constricted hyaline neck, the tip well distinguished blackish brown bent outward, the lips coarse subhyaline oblique outward. Receptacle nearly hyaline, except cell II and sometimes the upper part of cell I, long and slender geniculate above cell II. Insertion-cell broad, black, close to base of perithecial neck. Outer appendage consisting of a larger basal subtriangular cell becoming more or less suffused with olive-brown, surmounted by a series of five or six obliquely superposed hyaline cells which curves inward toward the perithecium; each cell of the series bearing externally a simple branch consisting of two short faintly brownish basal cells constricted at the blackish septa, and a

terminal hyaline tapering portion about twice as long: the inner appendage consisting of a basal cell blackened below, from which arises on either side a series of superposed cells like that of the outer appendage and similarly branched except that one or two of the lower cells of the series bear antheridia, single, sessile or on a one-celled stalk. Perithecia 200–285 × 37 μ (the neck, 18–20 μ, included). Total length to tip of perithecium 500–670 μ; to insertion-cell 275–370 μ; greatest width 55 μ. Spores 65–70 × 5 μ. Appendages 150–175 μ.

On *Galerita* sp., Paris Museum, No. 160, Rosario, Argentine Republic. On left side of inferior prothorax.

Laboulbenia gibbifera nov. sp.

Perithecium free or nearly so, somewhat narrower than in *L. Dercyli*, the apex narrower and more abruptly distinguished, the lips distinct, turned slightly inward; an external outgrowth just below the blackened tip, which it may exceed in length, forming a free protuberance straight or bent sidewise or inward, its apex evenly rounded or slightly inflated, its outer margin continuous with the nearly straight margin of the perithecium. Receptacle much as in *L. Dercyli*, more slender and shorter, the appendages pushed outward by the enlargement of cell V. Appendages much as in *L. Dercyli*, the basal cells projecting upward more prominently, a group of branches in almost all cases arising apparently from cell V or from a small cell separated from it, the lower segments of the branches clearly differentiated and bearing externally three to six external and terminal branchlets. Perithecium 150–167 × 50 μ. Total length to tip of perithecium 400–450 μ; to insertion-cell 275–340 μ. Appendages 150 μ.

On *Dercylus tenebriosus* Laf. (*Eurysoma tenebrioides*?), Hope Coll. No. 328, Para; Brit. Mus. No. 586, "S. America." Inferior surface of thorax and prothorax near base of two anterior pairs of legs. Possibly a variety of *L. Dercyli*.

Laboulbenia heterocheila nov. sp.

Perithecium olive-brown united to cell IV nearly to its base, rather short, inflated below, tapering distally, the tip not abruptly differentiated, blackened below, the four lip-cells all differently modified: of the two inner lips one produces an erect rather slender brown finger-like terminal outgrowth, the other a shorter much broader paler outgrowth turned inward nearly at right angles: of the two outer lips one forms merely a rounded

prominence while the other grows out into a large prominent brown blunt-tipped tooth-like projection which becomes bent slightly outward and sideways. Receptacle rather long and slender, suffused with brown, the darker distal portion marked by fine transverse indistinct striations. The basal cells of the appendages more or less indistinguishable and giving rise to indistinct prominences bearing numerous branches, the basal cells of which are short, inflated distally, and bear a terminal and external series of closely septate branchlets; the latter once or twice branched, the septa dark, the whole forming a dense tuft about half as long as the perithecium. Spores 60 × 6 μ. Perithecium 200 × 70 μ. Total length to tip of perithecium 550 μ; to insertion-cell 400 μ. Longest lip-prominence 35 μ.

On *Dineutes* ? sp., Brit. Mus. No. 486, Timor, E. Indies. Elytra.

Laboulbenia imitans nov. sp.

Perithecium free, long, rather slender, curved slightly outward, suffused with dark smoky brown, tapering rather abruptly to a somewhat truncate tip, the inner lip-cells darker, the basal cells forming a hyaline well developed neck. Receptacle short, stout, subtriangular, usually abruptly bent above the basal cell, becoming deeply suffused with blackish brown, coarsely and conspicuously punctate, except where quite opaque, the opacity first involving the anterior and lower portions above the hyaline basal cell: cells IV and V nearly equal, cell IV bulging outward more than half its upper surface, being free from and external to the black insertion-cell. Appendages not reaching the tip of the perithecium; the outer consisting of a hyaline basal cell which gives rise to an antero-posterior series of rigid rather slender slightly incurved branches about six in number, arising from a deeply blackened ridge of insertion; the branches becoming deeply suffused with blackish brown, except along their inner margins, closely septate, the lower cells giving rise distally and inwardly to secondary branches similar to the primary ones and often developing short hyaline branchlets in a similar fashion. The inner appendage consisting of a basal cell which gives rise on either side to a series of from two to three branches similar in character to those of the outer appendage: the whole forming a somewhat crest-like dense tuft. Spores 42 μ long. Perithecium (exclusive of neck) 150–155 × 28 μ; the neck 20–30 × 20 μ. Total length to tip of perithecium 270–340 μ; to insertion-cell 100 μ; greatest width 50 μ. Appendages, average 45 μ long.

On *Nycteis* sp., Paris Museum, No. 29, Madagascar. On legs, elytra, and abdomen. Resembling a species of *Corethromyces* in general appearance.

Laboulbenia insularis nov. sp.

Perithecium one third or more free, inflated, dark brown, becoming almost opaque, tapering to the rather pointed apex, the lip-edges hyaline. Receptacle elongate, the distal portion concolorous with the perithecium; cell I suffused with brown above and below, cell II hyaline except for a brown suffusion at its base and distal end. Outer appendage consisting of a large subconical basal cell becoming dark brown and bearing terminally a single short erect slender branch, the two basal cells of which are dark blackish brown, the septa usually oblique; the distal cell somewhat longer than the rest of the appendage, hyaline and soon broken. The inner appendage consisting of a very small basal cell, usually producing a single short hyaline branch about as long as that of the outer appendage. Perithecium 85–95 $\times$ 40 μ. Total length to tip of perithecium 215–275 μ; to insertion-cell 200–250 μ. Appendages, longest 100 μ.

On *Bembidium sublimatum* Woll., and *B. Grayanum* Woll., Brit. Mus. No. 409, Island of St. Helena.

Laboulbenia intermedia nov. sp.

Perithecium about three fourths free, suffused with yellowish brown deeper below the apex, rather stout, slightly inflated, the apex very broad, rounded, often almost flat, short, wholly blackened, the lips indistinguishable, the wall-cells with a slight spiral twist. Receptacle short and stout, at first hyaline below, becoming concolorous with the perithecium. Outer appendage consisting of a rather large subisodiametric cell bearing distally two or three antero-posterior branches, once or twice branched, the external branchlets brown, basally deeply blackened. Inner appendage consisting of a basal cell similar to that of the outer and producing usually two simple or once branched branches placed antero-posteriorly, the ultimate branchlets in both appendages elongate, tapering slightly distally, hyaline. Perithecia 95–105 $\times$ 35–40 μ. Total length to tip of perithecium, average 190 μ; to insertion-cell 120 μ. Appendages, longest 300 μ.

On *Anisodactylus tricuspidatus* A. Mor., Paris Museum, No. 199, Mon-Pin, (China?). Margin of the elytra.

Laboulbenia Italica nov. sp.

Perithecium free except at its base, rather short and stout, the upper half or third curved strongly outward, the tip large, sulcate, blackened, the lips coarse, nearly equal, subhyaline. Receptacle concolorous with the perithecium, the base nearly hyaline, usually bent between cells I and II, short, abruptly expanded above cell II, the anterior margin straight above cell I. Appendages arranged very much as in *L. orientalis*, the basal cells subtriangular, the outer producing externally an oblique row of about four superposed branches from a blackened area of insertion, the branches erect mostly twice subdichotomously branched, all the lower septa blackened and constricted, the inner appendage similar to the outer: the insertion-cell normally placed, broad, subhyaline, close to base of perithecium. Antheridia brown, the vente much inflated, the neck becoming pointed, $23 \times 8\,\mu$. Perithecia $100 \times 42\,\mu$. Total length to tip of perithecium $275\,\mu$; to insertion-cell $175\,\mu$. Appendages $140\,\mu$.

On *Brachinus explodens* Duft., Florence Museum, Florence, Italy.

Laboulbenia Javana nov. sp.

Perithecium about two thirds or less free, sessile, tinged with brown, paler in the middle, the distal portion hyaline and tapering considerably to the greatly modified tip, which is deeply suffused with blackish brown and bears two often symmetrically placed divergent outgrowths, the inner broader at the base and much shorter than the outer which is finger-like, with a hyaline area above, close beside the subterminal pore: the outer of these two projections appears, through a twist in the perithecium, to lie on the inner side. Receptacle pale yellowish with brownish shades, the deeply suffused base of the perithecium opposite the upper half of cell III or lower; the distal portion usually so twisted and bent in conjunction with the perithecium that it crosses the latter and the appendages at a considerable angle. Insertion-cell higher than the middle of the perithecium. Appendages concolorous with the receptacle, consisting of an outer basal cell which bears a single simple branch, slightly nodulose above and below the septa, the basal cell of the inner appendage smaller, bearing a single branch on either side which may be once branched. Perithecia about $100\,\mu$ long exclusive of outgrowth, $27\,\mu$ broad. Total length to tip of perithecium $190\,\mu$; to insertion-cell $140\,\mu$. Appendages $130\,\mu$. Distance from tip to tip of perithecial outgrowths 45–$48\,\mu$.

On *Pericallus cicindeloides* MacLeary, Paris Museum, No 143, Tongou, Java. On inferior surface of thorax.

Laboulbenia leucophæa nov. sp.

Perithecium dark brown, almost opaque, rather small, hardly more than the tip free from the receptacle; the tip relatively large and long, bent slightly outward, not abruptly differentiated, black except around the pore, the right inner lip forming a hyaline nearly median blunt outgrowth which is bent slightly outward. Receptacle sometimes twisted at the distal end of and above cell II; cell I hyaline; cell II suffused with brown, in some cases with deeper brown tranverse elevations on one side; the lower half of cell III and cell VI hyaline, the rest of the receptacle concolorous with the perithecium. The outer appendage simple, its basal cell four or more times as long as broad, curved toward the perithecium; the basal cell of the inner appendage very small, bearing in general a single short branch, both appendages pale yellowish. Perithecium to tip of outgrowth 130–150 × 35–40 μ. Total length to tip of perithecium 325–375 μ; to insertion-cell 250–290 μ; greatest width 55–65 μ. Appendages about 200 μ.

On *Serrimargo guttiger* Schaum., Hope Collection, No. 300, Sumatra. Mid-elytron and base of legs.

Laboulbenia Loxandri nov. sp.

Perithecium about three fourths free, suffused with brownish, translucent, the distal half narrow and strongly curved inward, especially at the tip, the latter externally and distally blackened, the lip-edges hyaline. Receptacle rather stout, pale dirty brownish; cell II basally and distally and cell VI externally more deeply suffused. Cells IV and V elongated so that they become parallel and carry the insertion-cell upward and outward free from the perithecium. Outer appendage consisting of a rounded basal cell bearing a single terminal branch, the basal cell and one or two cells above it rounded, constricted at the mostly blackened septa, simple or each of the lower cells producing distally on the inner side a branchlet, the branchlets and the terminal portion of the main branch hyaline, slender, thin-walled, tapering. Inner appendage consisting of a basal cell like the outer and like it producing a branch on either side. Spores about 45 × 4 μ. Perithecium 140 × 40 μ. Total length to tip of perithecium 340 μ; to insertion-cell 275 μ. Appendages, longest 120 μ.

On *Loxandrus unistigma* Bates, Brit. Mus. No. 659 (Biologia Coll.), Paso Antonio, Guatemala. Elytra.

Laboulbenia maculata nov. sp.

Perithecium free, dark brown becoming nearly opaque, the outer margin more convex than the inner; somewhat constricted at the base, the tip rather abruptly distinguished externally, the margins nearly straight, the inner lips small and prominent, the outer broad, straight, oblique. Receptacle abnormal, cell I short, slender, curved, opaque; cell II nearly hyaline in the middle, brownish above, coarsely spotted with blackish brown below, becoming darker and indistinguishable from cell I at its base; cell VI distally nearly hyaline and narrow, extending down beside cell II nearly if not quite to cell I, its base spotted as in cell II; cell VII (the "secondary stalk-cell") external to it, the margin blackish brown especially distally, extending down beside cell VI to within a short distance of its base where it is similarly punctate towards its base or throughout; cell III narrow, external to the upper two thirds of cell II, punctate below, its distal end close beside the corresponding termination of cell II; the base of cell IV overlapping cell III so that a cross section in this region would cut cells II, III, IV, VI, and VII: distal portion of the receptacle concolorous with the perithecium or somewhat paler. The perithecium bent toward and partly or wholly overlapping the insertion-cell. Appendages directed across the lower half of the perithecium sometimes at right angles; consisting of a large outer basal cell sometimes slightly inflated, bearing distally one or usually two antero-posterior simple branches which are slender, rather rigid, their diameter much less than that of the basal cell: the inner appendage consisting of a smaller basal cell which may produce one or two branches similar to those of the outer appendage; all the branches slender, rather rigid and straight, parallel and closely approximated, tapering but slightly. Perithecia $225 \times 60\,\mu$. Total length to tip of perithecium $560\,\mu$; to insertion-cell $375\,\mu$; greatest width $140\,\mu$. Appendages about $200–250\,\mu$.

On *Serrimargo guttiger* Schaum., Brit. Mus. No. 559, Penang, East Indies. On anterior legs.

Laboulbenia Madagascarensis nov. sp.

Perithecium free, mostly straight, the inner margin more convex, uniformly clear dark brown or blackish except just below the black tip, abruptly distinguished from and contrasting with the receptacle; the tip rather abruptly distinguished, straight or bent slightly inward, with hyaline lip-margins, the wall-cells with a slight spiral turn. Receptacle

hyaline or finally yellowish, cells III and VI about equal. Insertion cell opposite base of perithecium. Outer appendage consisting of a rather small basal cell, its outer wall blackened, the blackening continuous with the insertion cell, producing distally usually two branches, an outer blackened externally or suffused with brown at its base and once branched, and an inner usually simple and hyaline. The inner appendage consists of a basal cell like that of the outer, and produces a single branch on either side which may be once branched, all the branchlets of both appendages rather stout and stiff, tapering, slightly curved outward, hyaline or becoming dirty yellowish. Perithecia 100–120 × 40–45 μ. Total length to tip of perithecium 240–270 μ; to insertion-cell 140–155 μ. Appendages, longest 250 μ.

On a Carabid allied to *Harpalus*, Paris Museum, No. 3, Madagascar. On margins of both elytra.

Laboulbenia Madeiræ nov. sp.

Perithecium united to receptacle for about two thirds of its length, pale straw-yellow becoming brownish yellow, the whole tip clear contrasting black or blackish brown, the hyaline lip-edges turned outward. Receptacle concolorous with perithecium, rather short, normal. Cell V relatively large, its upper margin free between the perithecium and the insertion-cell, the latter oblique, clear black, contrasting. Outer appendage often simple, elongate, sometimes once branched above its subbasal cell; the branches divergent: inner appendage consisting of a basal cell smaller than that of the outer, and bearing one or two short branches commonly three-celled. Spores 75 × 6 μ. Perithecia 100–130 × 35–40 μ. Total length to tip of perithecium 225–250 μ; to insertion-cell 175–210 μ. Appendages, longer 350 μ.

On *Calathus complanatus* Dej., Paris Museum, No. 211, Madeira. On elytra.

Laboulbenia Malayensis nov. sp.

Perithecium clear translucent brown with a slight olive tinge, becoming almost opaque; united to the receptacle except the abruptly distinguished tip which is hyaline, except the blackened lips; the latter turned abruptly usually to the right, forming a lateral somewhat irregularly four-lobed papilla in which the hyaline pore is central. Cells I and II of the receptacle about equal in length, nearly hyaline, often distally olivaceous; cells III and IV relatively large, translucent olive-brown, cell IV bulging distally so that the dark but not opaque inser-

tion-cell is turned obliquely toward the tip of the perithecium; cells VI and the basal cells of the receptacle more or less tinged with olive-brown forming an elevation so that the perithecium appears indented below, all the cells except cell I marked by fine transverse striations. Outer appendage simple, the basal cell rather large, often externally indented near the base, the second and third cells nearly equal, narrower than the basal cell and the cells immediately above them; the rest of the appendage tapering to the hyaline attenuated elongate distal portion; the inner appendage consisting of a basal cell one third as large as that of the outer and bearing a single branch on either side, one or both of which may be elongate much like the outer appendage, bearing one or two short slender antheridial branches near the base which are bent rather abruptly upward from their point of origin; the branches all distally hyaline and attenuated; the basal cells faintly reddish. Perithecia, average 110 × 37 μ. Total length to tip of perithecium 260–280 μ; to insertion-cell 250–275 μ; greatest width 75 μ. Appendages, longest 375 μ.

On *Pericallus cæruleovirens* Tat., Brit. Mus. No. 570, Singapore. At base of posterior legs.

Laboulbenia melanaria nov. sp.

Perithecium nearly free, uniformly suffused with clear blackish brown, straight or bent slightly outward; the tip more deeply colored, the lip-edges hyaline, contrasting, externally oblique. Receptacle hyaline becoming yellowish, often suffused with blackish brown except the lower portions of cells I, III, and VI, and usually cell V. Outer appendage consisting of a basal cell mostly free, bearing terminally a single branch typically once branched above its basal cell, the branchlets elongate, thick-walled, rigid, more or less tinged with brown. The inner appendage consisting of a much smaller basal cell, producing either a short two-celled branch with one or two terminal antheridia, or two longer branches which may be once branched; the branches like those of the outer appendage but shorter. Perithecium 120 × 35 μ. Total length to tip of perithecium 275 μ; to insertion-cell 150 μ. Appendages, longest, 550 μ.

On *Diachromus germanus* Linn., Florence Museum, Florence, Hope Coll. No. 344½, 319, France, Portugal; on *Anisodactylus militaris*, No. 315, Sardinia; on *A. heros* Fabr., No. 316, "Europe."

Laboulbenia melanopus nov. sp.

Perithecium free except at the base, large, rather deeply suffused with smoky brown, translucent, not contrasting; the subdistal wall-cells lighter, tapering abruptly to the narrow somewhat incurved tip, the inner lip-cells only deeply blackened. Receptacle somewhat curved, tapering below to the short slender basal cell which is smoky black except at its base, the distal cells gradually suffused with yellowish brown. Insertion-cell opaque only externally, the basal cells of the appendages becoming apparently divided into several cells which are opaque or nearly so and indistinguishable in the mature plant, giving rise to numerous branches the basal cells of which are distally inflated and bear terminally numerous branchlets (about six to ten), the latter very slender, flexuous, not as long as the perithecium. Spores about $60 \times 4.5\,\mu$. Perithecium $290 \times 70\,\mu$. Total length to tip of perithecium $675\,\mu$; to insertion-cell $400\,\mu$. Appendages, longer $140\,\mu$.

On Carabid (allied to *Harpalus*?), Paris Mus. No. 115, Africa. On tip of abdomen.

Laboulbenia microscopica nov. sp.

Perithecium one half or wholly free, pale olivaceous, somewhat inflated, tapering to the relatively long narrow subtruncate blackened tip which is bent slightly inward. Lower half of receptacle greatly reduced in size, the basal cell hyaline or nearly so, the rest suffused with dark brown, cell III paler, cell II broader than long, cells III to V relatively large, bulging prominently outward beyond and below the insertion-cell. Outer appendage consisting of a basal cell which becomes sub-triangular through the protrusion of its upper outer angle which renders its distal margin twice as broad as the basal cell of the single branch which rises from its upper inner half. The inner appendage arising from a much smaller basal cell which produces two branches. Spores about $35 \times 3\,\mu$. Perithecia $75–93 \times 27–34\,\mu$. Total length to tip of perithecium $120–140\,\mu$; to insertion-cell $75–90\,\mu$. Greatest width $45–60\,\mu$. Appendages about $70\,\mu$.

On *Pelmatellus nitescens* Bates, Brit. Mus. (Biologia Coll.), No. 683, Vera Paz, Guatemala. On elytra.

Laboulbenia microsoma nov. sp.

Perithecium free, several times as large as the receptacle, smoky brown darker basally and distally, the longitudinal septa subhyaline, the outer margin concave, the inner convex; a subterminal external small rounded

elevation; the tip very broad, short, almost flat-topped, the outer angle almost a right angle, the inner rounded. Receptacle consisting of a basal cell which is nearly hyaline, above which cells II, III, and VI form an almost transverse row; cell II median, triangular, lying between the other two, the receptacle abruptly expanded in this region; cells III and IV small and flattened; cell V hardly distinguishable. Insertion-cell and basal cells of the appendages nearly opaque and indistinguishable from one another, the outer basal cell apparently producing two branches antero-posteriorly; the inner a branch on either side, all the branches (broken) brown, stiff, erect or slightly divergent. Perithecium 185 × 66 μ. Total length to tip of perithecium 295 μ; to insertion-cell 90 μ; greatest width 65 μ.

On *Serrimargo guttiger* Schaum., Brit. Mus. No. 560, Penang, East Indies. At base of posterior legs.

Laboulbenia minimalis nov. sp.

Perithecium free, becoming olivaceous brown, mostly straight, the basal wall-cells forming a very short stalk, the tip rather abruptly distinguished, mostly straight symmetrical black, distally hyaline. Receptacle olivaceous yellow with brown suffusions; cell I slightly suffused with brown, somewhat longer than cell II, both rather narrow; the receptacle expanding rather abruptly above cell II; cells III, IV, and V nearly equal becoming rather deeply suffused with brown. Insertion-cell broad, blackened. Outer appendage consisting of a large triangular basal cell becoming deep blackish brown, above which four to six small nearly hyaline cells obliquely superposed, or with their long axes nearly vertical, form a series which runs obliquely toward the perithecium, each cell producing externally a single branch; the branches either simple and mostly three-celled or branched above their basal cells; the branchlets two in number, mostly four-celled, their basal and terminal cells very small, all the septa somewhat dark, slightly constricted: the inner appendage consisting of a basal cell bearing on either side a short series of cells like that of the outer appendage and similarly branched, except that the three or four lower branches consist of a single cell bearing terminally a pair of rather stout long-necked antheridia; the three series closely apposed or united. Perithecia 100 × 30 μ. Total length to tip of perithecium 200–235 μ; to insertion-cell 110 μ; greatest width 45 μ. Appendages 60–75 μ.

On *Galerita* sp., Paris Museum, No. 74, Venezuela. On mid-elytron.

Laboulbenia Misceli nov. sp.

Perithecium free, long and slender, translucent, pale brownish olive, narrowed at the base to form a short paler stalk which lies opposite the insertion-cell; the tip long, not very abruptly distinguished, paler below, straight or turned slightly outward, distally blackened on the inner side; the lips variable, rather prominent. Receptacle rather short and stout, darker olive-brown; the basal cell pale yellowish. Insertion-cell nearly as broad as cells IV–V. Basal cell of outer appendage blackish brown externally, bearing a single terminal branch of less diameter externally suffused with blackish brown, slightly curved outward and bearing two or three branchlets from the inner side which are hyaline, the basal cells somewhat suffused with brown; the basal cell of the inner appendage smaller than that of the outer, nearly hyaline and bearing a branch on either side similar to the outer appendage. Perithecia including base 145–180 μ. Total length to tip of perithecium 240–300 μ; to insertion-cell 90–130 μ; greatest width 35–40 μ. Appendages, longer 150 μ.

On *Miscelus* sp., Paris Museum, No. 114, Isles des Moluques. At base of posterior legs.

Laboulbenia obtusa nov. sp.

Perithecium about three fourths free, becoming opaque, black-brown, very stout, the outer margin slightly and more or less symmetrically convex, the inner bulging prominently distally and curved abruptly to the brown blunt rounded hardly differentiated apex, the pore external. Receptacle short, cell VI together with the basal cells of the perithecium concolorous with the latter, becoming indistinguishable; cell VI extending to or towards the base of cell II, which is mostly suffused above, hyaline and contrasting below as is cell I; cells III and IV with median brown shades. Insertion-cell black-brown. Appendages hyaline becoming tinged with brown, the outer basal cell twice as long as the inner, each bearing one to two branches which form a compact group curved toward and against the perithecium. Perithecium 120 × 65 μ. Total length to tip of perithecium, average 260 μ; to insertion-cell 175 μ. Appendages, broken, 35 μ.

On *Aerogenidion Bedeli* Tsch., Paris Museum, No. 198, Mon-Pin, (China?). On left inferior margin of prothorax.

Laboulbenia Œdodactyli nov. sp.

Perithecium free except at the base, pale transparent amber-yellow, somewhat inflated at the base and tapering gradually thence to the

slender tip, a blackish shade below the nearly hyaline lips which are turned slightly outward. Receptacle amber-colored, deeper anteriorly, cell II sometimes elongate, cell VI very short, so that the base of the perithecium comes opposite cell III. Insertion-cell and the inner margin of cell V usually free from the perithecium. The outer appendage simple divergent, the basal cell very large; the basal cell of the inner appendage much smaller, bearing one to two short branchlets. Spores 35–40 × 41 μ. Perithecia 120 × 35 μ. Total length to tip of perithecium 175–380 μ (longest); to insertion-cell 115–275 μ.

On "*Œdodactylus fuscobrunneus*," Brit. Mus. No. 397, Chili. On elytra.

Laboulbenia Oopteri nov. sp.

Perithecium three fourths or more free, translucent blackish brown, the inner margin evenly curved outward, the outer margin with slight elevations at the septa and curved abruptly inward to form the well differentiated tip which is pale brownish, with dark inferior suffusions. Receptacle concolorous with perithecium, except that cells I and II are usually hyaline, the suffused portions sparsely and rather coarsely and distinctly punctate. Insertion-cell broad and black. Basal cell of the outer appendage for the most part very long, bearing distally an outer and an inner branch, the former with blackened basal septum, simple, or once branched in which case the basal septum of the outer branchlet is also blackened. Inner appendage consisting of a very small basal cell bearing a short branch on either side. Perithecia 95–110 × 30–35 μ. Total length to tip of perithecium 175–275 μ; to insertion-cell 85–160 μ. Appendage broken, 200 μ, probably much longer.

On *Oopterus rotundicollis* White, Brit. Mus. No. 613, New Zealand. On elytra.

Laboulbenia Ophoni nov. sp.

Perithecium free except at the base, short and stout, pale straw-colored or nearly hyaline, somewhat inflated; the inner margin more convex, the black tip abruptly differentiated on its inner side, black, contrasting, the lip-edges hyaline turned slightly outward. Receptacle short, stout, normal, concolorous with the perithecium. Insertion-cell black, contrasting. The outer appendage divergent, simple or once to three times branched, the ultimate branchlets distally attenuated; the inner appendage consisting of a basal cell half as large as that of the outer, bearing a short branch on either side which may be several times branched, the antheridia borne in small groups. Spores 28 × 3 μ. Perithecia 70 × 30–34 μ. Total

length to tip of perithecium 165 μ; to insertion-cell 85–100 μ; width 40 μ. Appendages, longest 200 μ.

On *Ophonus obscurus* Fabr., *O. brevicollis* Dej., *O. azureus* Fabr., *Harpalus neglectus* Dej., *H. serripes* Quensel, *H. sulphuripes* Germ., *H. tardus* Panz., in Florence Museum collection of Italian Coleoptera. On *Ophonus* sp.?, Interlaken, Switzerland. On *Ophonus* sp., Paris Museum, No. 37, Algeria. On elytra, inferior thorax and prothorax, and abdomen.

Laboulbenia Orectochili nov. sp.

Perithecium free except at the base, more or less evenly suffused with smoky brown, with a subterminal external blackish patch, nearly symmetrical and straight, slightly inflated, tapering gradually to the hyaline tip which is surmounted by a median straight pointed purplish tooth-like projection formed by the outgrowth of one of the lip-cells; the inner lip-cells forming a small hyaline or partly purplish lateral papilla. Receptacle elongate, cells I and II stout, the latter slightly if at all narrower distally, cells IV and V and the basal cells of the perithecium darker brown, the rest very pale yellowish or purplish brown, finely punctate, the dots scarcely visible except in the more deeply suffused areas. The insertion-cell broad, blackened, extending completely across the distal margins of cells IV and V. Appendages consisting of an inner and outer basal cell, giving rise in all to from five to ten erect subconical prominences, each of which becomes separated as the basal cell of a very short two-celled branch of which only a blackened basal portion remains in mature specimens, the rounded purplish slightly inflated terminal portion of the upper cell usually breaking off above its blackened slightly constricted basal half. Of the branches that borne by the protuberance first formed from the outer basal cell is always somewhat larger and more prominent than the rest. Perithecia 190 × 59 μ. Total length to tip of perithecium 475–680 μ; to insertion-cell 400–550 μ.

On *Orectochilus cordatus* Reg., Paris No. 99, "Asia." On elytra.

Laboulbenia orientalis nov. sp.

Perithecium straight, its base free from and higher than the insertion of the appendages, straight to strongly recurved, becoming suffused with pale brownish; the tip blackish brown in normal specimens, well distinguished, with prominent lips (when curved, not abruptly distinguished, somewhat pointed, with ill defined lips), the translucent edges dirty brown. Receptacle hyaline or concolorous with the perithecium, sometimes be-

coming dark smoky brown; cell V often as large as cell IV, pushing the small subtriangular unmodified insertion-cell outward so that it may become lateral, with its transverse diameter vertical, cell VII unusually large. Appendages consisting of an outer and an inner basal cell, the two free from one another except at the base, mostly several times as long as broad and overlapping slightly; the outer bearing an external row of superposed branches, usually seven or eight in number, formed by the successive proliferation of the tip of the basal cell, and separated from it by broadly blackened septa; the branches successively subdichotomously branched several to eight or more times, the basal and sometimes the subbasal cell often producing more than two branchlets (two to four) superposed in a single row. The inner appendage like the outer, the basal cell producing a single similar row of branches fewer (usually two to four) in number, overlapping those of the outer appendage and bearing antheridia in groups of from one to eight not characteristically grouped, the venter rather abruptly distinguished from the straight cylindrical purplish neck: the branches of both appendages directed outward, hyaline or distally reddish or purplish, constricted at the lower purplish septa. Perithecia (largest) $230 \times 55\,\mu$; average $170 \times 40\,\mu$. Total length to tip of perithecium very variable, from $275\,\mu$ to 1 mm. Appendages 200–$350\,\mu$. Antheridia $16 \times 4\,\mu$.

On *Brachinus Chinensis* Chaud., Paris Museum, Nos. 58, 59, Manila, Philippine Islands, and Macao, China. Brit. Mus. Nos. 536 (bis), China. Hope Coll. No. 244, China. On *Brachinus* spp., Brit. Mus. Nos. 537, 539, 540, China and Philippine Islands. Usually on inferior surface of thorax and prothorax.

Laboulbenia Orthomi nov. sp.

Perithecium free, long and straight, slender, sometimes slightly inflated distally, deep clear brown; the tip broad, prominent, not abruptly differentiated; the lips rather large and prominent, the lower wall-cell as a rule elongated to form a hyaline neck, usually well marked and contrasting with the body of the perithecium. Receptacle shorter than the perithecium, olive-brown, except the hyaline or slightly yellowish basal cell. Insertion-cell not as broad as cell IV. The outer appendage consisting of a basal cell longer than broad, blackened externally, producing usually a single simple terminal branch, the two lower cells of which are blackened externally and sometimes give rise to erect simple branchlets. The inner appendage consisting of a basal cell similar to that of the outer, and producing on either side a straight hyaline erect branch. Spores 50 ×

4 μ. Perithecia 130–140 × 30–35 μ exclusive of the variably developed neck, which may be 18 μ long. Total length to tip of perithecium 260 μ; to insertion-cell 100 μ; width 40 μ. Longer appendages 200–270 μ.

On *Orthomus aquilus* Coquer, Algeria ?, Paris Museum, No. 41. On margin of elytra.

Laboulbenia pallida nov. sp.

Perithecium almost wholly free from the receptacle, colorless becoming faintly yellowish, bent outward; the prominent tip abruptly distinguished, coarse lipped, hyaline except for an inner blackish patch. Receptacle concolorous with the perithecium, the basal cell large and broad, longer than cell II, the cells of the distal portion relatively small, cell III roundish, about as large as cells IV and V together. Insertion-cell thick, contrasting purplish black. Outer appendage consisting of a basal cell, rectangular or distally enlarged and producing usually two, sometimes but one branch, the branches once or even twice branched, the ultimate branchlets sometimes very elongate and attenuated: the inner appendage consisting of a basal cell much smaller than that of the outer and sometimes lateral in position, bearing one or two branches which may be short or elongate like those of the outer appendage. Perithecia 70 × 25 μ. Total length to tip of perithecium 110–175 μ; to insertion-cell 85–120 μ. Appendages, longest 285 μ.

On a Carabid allied to *Harpalus*, Paris Museum, No. 94, Java. On elytra.

Laboulbenia Papuana nov. sp.

Perithecium nearly two thirds free, straight or curved slightly outward, the inner margin convex; pale brownish yellow, the tip rather well differentiated, blackish; the hyaline irregularly prominent lip-edges turned inward. Receptacle elongate, cell II, and cell I except at its base, conspicuously tinged with blackish and faintly marked by fine transverse striations, the rest of the receptacle concolorous with the perithecium; cell IV externally concave, the whole receptacle more or less prominently bent anteriorly in the region of cells III and VI. Insertion-cell broad, horizontal, black, narrower than cells IV–V. The basal cells of the appendages simple and distinct, the outer producing a single branch which may branch once; the branchlets short; the basal cell of the inner appendage producing two small branches which may be once branched. Spores about 65 × 5.5 μ. Perithecium 160–200 × 55–65 μ. Total length to tip of perithecium 650–880 μ; to insertion-cell 544–700 μ. Appendages, longest seen, 140 μ.

On *Morio* sp., Paris Museum, No. 112, New Guinea. On anterior inferior surface of thorax on right side.

Laboulbenia Pericalli nov. sp.

Perithecium becoming almost opaque, its upper fourth, sometimes only the tip, free from the receptacle, relatively small, the tip more or less prominent, sometimes subconical, short, and wholly black (often more prominent, abruptly distinguished, the rounded lips well defined with hyaline edges). Receptacle normal, cells III and IV large and broad, concolorous with the perithecium; cells I and II together with the lower end of cell VI pale yellowish. Outer appendage mostly simple, stout, the lower cells slightly inflated; inner appendage consisting of a much smaller basal cell, bearing a usually simple branch on either side very similar to the outer appendage; all the branches yellowish or becoming tinged with brown, especially toward the base. Perithecia 110–130 × 37–45 μ. Total length to tip of perithecium 200–300 μ; greatest breadth about 75 μ.

On *Pericallus guttatus* Chev., Paris Museum, No. 78, Java; on *Miscelus* sp., Paris Museum, Nos. 113, 114, 115, New Guinea.

Laboulbenia platystoma nov. sp.

Perithecium free except at the very base, straight, rather long and narrow, pale amber-yellow becoming slightly tinged with brown, slightly and symmetrically inflated; the tip black, opaque, the lip-cells forming an abruptly spreading almost flat symmetrical termination with a slight median indentation, two of the lips forming a small median hyaline truncate cone, the other two arching over them from the outer and inner side, wholly opaque except their inner margins, the blackened part not quite meeting in the median line, the whole resembling the end of a pair of horizontal cut plyers. Receptacle medium, pale amber-yellow becoming tinged with brown distally. Outer appendage mostly simple, the basal cell about twice as long as broad, often slightly inflated, the rest of the appendage much narrower, straight, rigid, tinged with brown tapering somewhat distally; the inner appendage consisting of a basal cell about half as long as that of the outer, producing a branch on either side; the branch usually bearing an antheridial branchlet near its base, the branches and the outer appendage similar, often curved slightly outward, becoming tinged with brown. Perithecia 175 × 40 μ; the tip 37 μ broad. Total length to tip of perithecium 325–400 μ; to insertion-cell 185–230 μ; greatest width 55–63 μ. Appendages about 175 μ (longest).

On *Catoscopus* sp., Paris Museum, No. 119, New Guinea. On inferior surface.

Laboulbenia Polyhirmæ nov. sp.

Perithecium rather slender, almost wholly free, nearly hyaline or faintly brownish yellow; tapering slightly toward the moderately well differentiated tip which is usually bent slightly outward, more or less blackened on the inner side, sometimes wholly black, the inner lips often prominently rounded and terminal. Receptacle concolorous with the perithecium, marked by faint transverse striations, long and slender; cell II usually greatly elongated; the distal portion small and normal. Outer appendage consisting of a small basal cell more or less rounded and producing distally from two to four branches, usually four; an outer and an inner, the two others placed between them one on either side, the branches simple or usually not more than once branched above the basal cell; the branchlets slender, often flexed, rather closely septate, hardly tapering: the inner appendage consisting of a smaller rounded basal cell which produces on either side a single branch, which may branch several times and bears hyaline lateral or terminal antheridia singly or in pairs; all the branches nearly hyaline. Perithecia 130–190 × 30–40 μ. Total length to tip of perithecium 400–700 μ, average 500 μ, to insertion-cell 275–450 μ. Appendages, longest 350–400 μ. Greatest width 40–50 μ.

On *Polyhirma* sp., Paris Museum, Nos. 5, 6, and 168, Tangar, Algeria. On inferior surface of abdomen and thorax especially in depressions at base of posterior legs.

Laboulbenia prominens nov. sp.

Perithecium short and stout, less than half free from the receptacle, nearly opaque blackish brown lighter distally, the short broad blunt black tip rather abruptly distinguished on the inner side. Receptacle rather stout, cells I and II dirty yellowish or subhyaline, the rest more or less deeply suffused with blackish brown; all the cells except cell I marked by fine transverse striations more distinct on the suffused portions; cells III and IV large and prominent, the insertion-cell broad but narrower than cells IV–V. Outer appendage consisting of a short irregular cell abruptly narrowed distally and bearing two branches antero-posteriorly, the outer externally deep blackish brown, once branched; the outer branchlet also branched, the inner consisting of a short basal cell which bears an inner and an outer branchlet, the branchlets pale

brown, curved outward: the inner appendage consisting of a basal cell smaller than that of the outer, irregular and bearing a branch on either side; each once branched, the branchlets like those of the outer appendage. Perithecia $150 \times 52\,\mu$. Total length to tip of perithecium 310–330 μ; to insertion-cell 275 μ. Greatest width 95–100 μ.

On *Pericallus guttatus* Chev., Brit. Mus. No. 571, Java. On legs.

Laboulbenia protrudens nov. sp.

Perithecium smoky brown with a tinge of olive, the outer margin concave, relatively small; the tip only free from the receptacle, short, rounded, not abruptly differentiated, bent slightly outward, black except around the pore. Receptacle dirty olivaceous; cell I, except at the base, concolorous with perithecium; cells IV and V forming a somewhat angular protrusion which carries the insertion-cell out free from and beyond the tip of the perithecium. Insertion-cell less than half as broad as the adjacent distal margins of cells IV and V, which form a flat surface in which the insertion-cell is mostly central. Outer appendage arising from a small roundish basal cell, simple or once branched, the branches short, tapering nearly hyaline; the basal cell of the inner appendage very small bearing one or two short tapering hyaline branches. Perithecia 95–110 $\times$ 34 μ. Total length to tip of perithecium 280 μ; to insertion-cell about the same measurement; greatest width 66 μ.

On *Pericallus cicindeloides* MacLeary, Paris Museum, No. 144, Tongou, Java. On mid-elytron.

Laboulbenia Pseudomasci nov. sp.

Perithecia dark rich brown, slightly and rather evenly inflated, divergent, free from the receptacle except at the very base, the broad opaque tip hardly differentiated; the lip-edges nearly hyaline, not prominent, turned slightly outward. Receptacle colorless or yellowish below, distally brownish, slender, its axis coincident with that of the appendages; cell I usually larger and longer than cell II, the rest of the receptacle relatively unusually small, the inner margin of cell V partly free from the perithecium. Insertion-cell free, black. Outer appendage consisting of a basal cell several times longer than it is broad, which may branch above its basal or subbasal cell one to three times successively, the branchlets divergent; the inner appendage consisting of a much shorter basal cell bearing one or rarely two branches, sometimes simple, mostly one to three times branched, all the branches becoming more or

less suffused with brown. Spores about $65 \times 45\,\mu$. Perithecia 120–165 $\times\ 60\,\mu$. Total length to tip of perithecium 225–300 μ; to insertion-cell 170–240 μ. Appendages, longest 100 μ.

On *Pseudomascus nigrita*, Fab., Paris Museum, No. 201, Mongolia. Near upper inferior margin of prothorax on left side.

Laboulbenia punctata nov. sp.

Perithecium free, straight, translucent brown becoming almost opaque, except the broad short neck formed by the basal wall-cells, which is nearly hyaline and as broad as the ascigerous portion; the lower half or more of the suffused body of the perithecium covered with irregular more or less rounded dark spots, irregularly distributed, the lower larger; the tip rather abruptly distinguished, narrow, black, distally translucent. Receptacle rather short and stout, the basal cell rather narrow and hyaline or yellowish, contrasting; the rest of the receptacle subtriangular and deeply suffused; cell VI paler, cells III and IV side by side, nearly vertical, almost opaque, except the upper edge; cell V very large, subhemispherical, becoming opaque; all the suffused cells where not opaque, more or less conspicuously and rather coarsely punctate. Insertion-cell very broad, black, close beside the base of the perithecial stalk. Outer appendage consisting of a large triangular basal cell externally blackish brown, forming the base of a series of (eight or less) much smaller cells obliquely superposed, which curves toward the perithecium; each cell producing externally a single simple erect branch, rather closely septate, the (usually six) septa dark, constricted, the terminal cell short with rounded apex. The inner appendage consisting of a basal cell giving rise to a series of cells on either side like that of the outer appendage, but shorter, one to three of the lower branches consisting of a single cell bearing terminally a long slender flask-shaped brown antheridium. Perithecia 200–220 $\times\ 40\,\mu$; smaller $130 \times 48\,\mu$ (including the neck about 35 μ). Total length to tip of perithecium, average 350 μ; to insertion-cell 145 μ; greatest width 75 μ. Appendages 110–130 μ.

On *Galerita* sp., Paris Museum, No. 74, Venezuela, No. 136, "South America." On head.

Laboulbenia punctulata nov. sp.

Perithecium about three fourths free, dark brown translucent, curved toward the appendages which cross it obliquely, the broad short flat-

topped snout-like tip slightly upcurved. Receptacle short and stout, the basal cell small, short, hyaline, contrasting, the rest concolorous with the perithecium, but darker and distinctly punctate with dark brown spots. Outer appendage consisting of a series of from three to about six successively smaller superposed cells, from each of which a simple tapering brown branch arises, blackened about its subbasal septum, the successive branches superposed in a vertical external row as in *L. Pachytelis*, the basal cell of the inner appendage producing usually a short one-celled antheridial branch. Perithecia $120 \times 45\ \mu$. Total length to tip of perithecium $200–220\ \mu$; to insertion-cell $125\ \mu$. Appendages $100–120\ \mu$.

On *Pachyteles parallelus*, Chaud., Brit. Mus. No. 575, Para: on *P. porrectus* Chaud., Brit. Mus. No. 670 (Biologia Coll.), Pantaleon, Guatemala. On legs.

Laboulbenia pygmaea nov. sp.

Perithecium dark brown becoming almost opaque, coarsely punctate throughout or only toward the base, the basal wall-cells forming a well defined hyaline contrasting short neck slightly narrower than the body of the perithecium, the tip usually not very abruptly distinguished and bent very slightly outward, or straight, rather blunt, the lip-edges translucent, the lip-cells blackened below, especially on the inner side. Receptacle very short and subtriangular, cell I short, slender, curved, hyaline at the base, distally becoming opaque blackish and indistinguishable from cell II, which is wholly opaque. Cells III and IV elongated and lying obliquely side by side, cell III forming a more or less prominent rounded projection a little below the insertion-cell, both cells becoming opaque; cell V rather large, at first hyaline, becoming later suffused with brown; all the other suffused parts rather coarsely punctate. Insertion-cell black, very broad, often becoming indistinguishable from the basal cells of the appendage. Outer appendage consisting of a subtriangular basal cell distally rounded, becoming deeply suffused with blackish brown, prominent externally; surmounted by a series of obliquely superposed cells close set, their long (transverse) axes sometimes almost perpendicular, each bearing externally a single simple branch, the two lower cells of which are longer than broad, tinged with brown, the septa dark and often oblique; the distal portion hyaline, twice as long, blunt-tipped: the inner appendage consisting of a smaller basal cell also becoming almost entirely suffused, surmounted on either side by a series of cells like that of the outer appendage and similarly branched,

except that the two or three lowest cells of the series bear a short one-celled branch terminated by usually three slightly curved brown antheridia. Spores 52 × 4 μ. Perithecia 110 × 22–150 × 33 μ, exclusive of neck which is 20–30 μ. Total length to tip of perithecium 175–300 μ; to insertion-cell about 90–110 μ; greatest width 40–55 μ. Appendages 90–130 μ.

On *Trichognathus* sp., Paris Museum, No. 72, Venezuela. On "*T. marginatus*," Brit. Mus. No. 526, Brazil; on *T. marginipennis* Latr., Brit. Mus. No. 525, Tamaz, S. America; on *Galerita occidentalis* Oliv., Brit. Mus. No. 515, Bolivia; on *Galerita* sp., Hope Coll., No. 258, Bahia, Brazil. On all parts of host.

Laboulbenia rhinophora nov. sp.

Perithecium large and stout, dirty smoky brown, the lower half much deeper and united to the receptacle, the base nearly opaque, one of the subterminal wall-cells forming a terminal blunt finger-like brown outgrowth, close beside the rather small internally blackened tip, which it exceeds in length. Receptacle stout, the basal cell small hyaline; a blackish brown suffusion becoming opaque involves the upper part of cell II, cells III, VI, and VII, as well as the basal cells of the perithecium; cells IV and V very large and nearly parallel, translucent; the suffused parts, when not opaque, marked by darker transverse dots and striæ. Insertion-cell very large, triangular, quite unmodified. Appendages consisting of two basal cells concolorous with insertion-cell, the outer usually somewhat larger, both protruding upward and slightly overlapping, producing directly numerous branches (four to eight from each cell) which arise in more than one row from their outer surfaces; all the branches once to twice branched, the lower segments deeply constricted at the purplish septa, the distal cells without constrictions at the hyaline septa. Spores 75 × 5 μ. Perithecia to tip of protuberance 275–300 × 85 μ; to insertion-cell 300–340 μ. Appendages about 200 μ.

On *Brachinus* sp., Hope Coll. No. 252, Madagascar. On legs.

Laboulbenia rostellata nov. sp.

Perithecium about one half free, becoming more or less deeply suffused with blackish brown, relatively small, narrow and curved toward the appendages, the tip monstrously developed, bulging terminally and externally to form a rounded prominence from the inner side of which a blunt blackened outgrowth is developed, the hyaline contrasting tip of

which is bent slightly upward. Receptacle more or less suffused, sometimes deeply colored with blackish brown, cells I and II paler, slender, of nearly equal width, cell II longer; cells IV and V very broad, carrying out the insertion-cell free from the receptacle so that it becomes oblique or even vertical and lateral. Outer and inner appendages similar, bent away from the perithecium, their bases overlapping; consisting of a series of superposed cells which are sucessively smaller from below up, each bearing distally and externally a short tapering branch; all the branches brown, the subbasal septa blackened, all simple except the lower branch of the outer appendage which bears two to three short branchlets; the basal cell of the inner appendage bears a short antheridial branch from its inner side; the outer appendage somewhat longer than the inner, the superposed cells usually eight in number. Perithecia 140–190 × 40–45 μ. Total length to tip of perithecium 400–550 μ; to insertion-cell 270–450 μ. Appendages, 140–170 μ. Tip of perithecium, including outgrowth, 50–60 μ.

On *Brachinus lateralis* Dej., Hope Coll. No. 246, "North America"; on *Brachinus* sp., Eustis, Florida, October. At base of anterior legs.

Laboulbenia separata nov. sp.

Perithecium pale olivaceous, the inner margin convex, the outer nearly straight; the tip rather abruptly distinguished, blackened, but not uniformly, below the inner lip-edges, prominent olivaceous translucent, the right inner lip prolonged to form a slender nearly hyaline projection, the tip of which is blunt and somewhat swollen. Receptacle dull olivaceous, cells II, III, and IV sometimes becoming blackish brown externally, cells III and IV rather large; the insertion-cell close to the base of the perithecium, half as broad as cells IV and V. Appendages much as in *L. fissa*, the outer curved strongly outward, opaque and indistinguishable from the insertion-cell, bearing three or four branches from its convex side which are mostly once branched (the outer appendage usually broken); the inner appendage consisting of a small basal cell, bearing a branch on either side externally blackened, somewhat curved outward, and bearing three or four branchlets which are curved toward the perithecium, externally or wholly brownish toward the base. Perithecia 100–110 × 25–30 μ. Total length to tip of perithecium 220–260 μ; to insertion-cell 130–165 μ; greatest width 55 μ. The prolongation of the lip-cell extending about 20 μ or more beyond the tip of the perithecium.

On *Pericallus guttatus* Chev., Brit. Mus. No. 571, Java. Margins of elytra.

Laboulbenia Serrimarginis nov. sp.

Perithecium about three fourths free, dull olive-brown, the outer margin nearly straight, the inner bent rather abruptly below the tip; the latter not abruptly distinguished, broad, blunt, the lips not well defined, dull blackish. Receptacle dull olive-brown, except the almost hyaline rather slender basal cell; the rest of the receptacle short and stout, concolorous with the perithecium, cell VI broad and extending down to cell I beside cell II, cell VII extending half way down cell VI externally, the septa of cells III and IV oblique; cell III extending up to the base of cell V. Appendages as in *L. maculata*, stouter, brown, darker or blackish toward the base. Perithecia 136 × 50 μ. Total length to tip of perithecium about 300 μ; to insertion-cell 190 μ; greatest width 85 μ. Appendages 260 μ.

On *Serrimargo guttiger* Schaum., Brit. Mus. No. 558, Penang, East Indies. At base of anterior legs.

Laboulbenia speciosa nov. sp.

Perithecium free, long and narrow, the inner half or less hyaline, the outer dark clear blackish brown; the basal wall-cells forming a short hyaline stalk narrower than the ascigerous portion; the tip hardly distinguished, bluntly rounded, slightly oblique outwardly, black, hyaline about the pore. Receptacle very elongate, hyaline except cells IV and V which are tinged with amber-color and indistinctly punctate, as is cell III; cell II very elongate. Insertion-cell black, just free from the stalk of the perithecium through the slight enlargement of cell V. Outer appendage consisting of a series (in the unique type) of eight cells superposed not very obliquely, the basal one larger tinged with brown below, the rest hyaline; all the cells producing externally a single simple branch, the lower three cells of which are mostly not longer than broad, constricted at the black septa, distally faintly brownish yellow; the inner appendage consisting of a basal cell which bears on either side a series of four cells like that of the outer appendage, and bearing similar branches in a similar fashion, the three series quite distinct from one another. Perithecium, including its short neck, 280 × 55 μ. Total length to tip of perithecium 925 μ; to insertion-cell 650 μ. Appendages about 200 (–250) μ.

On *Galerita unicolor* Dej., Brit. Mus. No. 517, Brazil. On inferior surface of the prothorax.

Laboulbenia spiralis nov. sp.

Perithecium one half to one third (sometimes only the tip), free from the receptacle, dark dull amber-brown with dirty brown suffusions, rather stout, the tip moderately well distinguished, rather short and stout, deep black-brown, except the distal hyaline lip-edges. Distal portion of the receptacle concolorous with the perithecium; cells I and II much paler; cell I longer than cell II, the two forming a rather slender stalk of about the same diameter throughout, above which the distal portion of the receptacle is somewhat abruptly distinguished; the lighter portions marked by fine transverse striations not visible in the deeply colored often opaque distal region. Outer appendage consisting of a main straight divergent axis formed by usually three nearly equal cells, deeply blackened externally, bearing distally and from each of their upper inner angles a very long slender erect simple branch which is reddish brown, paler and spirally twisted distally. The inner appendage consisting of a basal cell about as large as that of the outer appendage and bearing on either side a branch which may give rise to one or two erect simple branchlets similar to the branches of the outer appendage. Perithecia about 150 × 55 μ. Total length to tip of perithecium 300–390 μ; to insertion-cell 275–325 μ. Appendages, longest 480–610 μ.

On *Hexagonia* sp. ?, Hope Coll., No. 288, Ceylon (Thwaites).

Laboulbenia strangulata nov. sp.

Perithecium one third to one half free, dark brown, concolorous below with the distally almost opaque receptacle; symmetrical, straight; the tip undifferentiated, bluntly rounded except for a hyaline flattish terminal papilla formed by the projection of one of the external lip-cells. Receptacle slender, cell I usually basally curved, broader at the distal end where it is rather deeply suffused with brown; cell II much longer, its lower two thirds often distinctly inflated, deep brown distally, rather abruptly constricted to less than half its greatest diameter, the constricted portion hyaline, the short remaining portion above the constriction becoming deep brown, concolorous with the upper portion of the receptacle. Insertion-cell normal as in *L. Orectochili*, oblique, often concave above, the appendages consisting of an outer and an inner basal cell, the two producing in all from three to six outgrowths as in *L. Orectochili*, somewhat narrower, hyaline except the first one formed from the outer basal cell which is always external to those subsequently formed and is

often divergent, deep brown, the suffusion involving the basal cell which bears it: each branch consists of a single simple cylindrical cell the distal portion of which is usually broken off leaving the deep brown contrasting base. Spores $60 \times 4.5\,\mu$. Perithecium $120–140 \times 40–45\,\mu$; to insertion-cell, average $275\,\mu$. Appendages $100\,\mu$.

On *Orectochilus*?, Brit. Mus. Nos. 480 and 484, Timor, East Indies. Margin of elytra.

Laboulbenia subconstricta nov. sp.

Perithecium less than one half free, rather small, curved strongly and evenly toward the appendages, evenly suffused with dark brown or lighter distally; the tip black, not abruptly distinguished, the lips distinct with a broad hyaline margin about the pore. Receptacle dull amber-yellow, cells IV and V, sometimes cell III, less deeply suffused with brown; cell I narrow, straight, but slightly enlarged distally; cell II abruptly much larger, symmetrically and prominently constricted in the middle; cells III and IV large and broad. Outer appendage simple, the basal cell moderately large; externally or wholly blackened; the rest of the appendage straight, rigid, directed across the tip of the perithecium: inner appendage consisting of a smaller basal cell which bears one or two branches similar to the outer appendage. Perithecia $85 \times 25\,\mu$. Total length to tip of perithecium about $200\,\mu$; to insertion-cell $165\,\mu$; greatest width $50\,\mu$. Appendages, broken, about $150\,\mu$ or a little more.

On *Catoscopus* sp., Paris Museum, No. 116, New Guinea. On anterior inferior margin of thorax on the right side.

Laboulbenia Sumatræ nov. sp.

Perithecium small, pale amber-colored, darker and somewhat inflated below, tapering distally; the tip only free from the receptacle not distinguished from the body of the perithecium, long, nearly hyaline below, the lip-cells abruptly spreading, contrasting, black except about the pore and peculiarly modified, the two outer broadly rounded, the two inner developing outgrowths which grow inward and upward; that on the right side longer than the left, narrower and indented near the base on the inner side. Receptacle concolorous with the perithecium, paler below, marked by faint fine tranverse striations. Appendages concolorous with the receptacle, the outer simple, stiff, curved slightly outward, the inner consisting of a basal cell smaller than that of the outer and bearing on either side a branch which may be once branched at the base.

Perithecium $92 \times 22\,\mu$. Total length to tip of perithecium $200\,\mu$; to insertion-cell $166\,\mu$. Appendages about $185\,\mu$.

On "*Catoscopus cupripennis* Thom.," Hope Collection, No 291, Borneo No. 299, Sumatra. At base of anterior legs.

Laboulbenia Tænodemæ nov. sp.

Perithecium nearly free, slightly inflated, clear translucent brown; the tip abruptly differentiated, externally black with an inner inferior hyaline patch, the lips well distinguished hyaline, the inner prominent, rounded, the pore external. Receptacle long and slender through the elongation of cell II, pale dirty yellowish brown or nearly hyaline. Insertion-cell large, free, blackish, hardly narrower than cells IV and V. Appendages concolorous with the receptacle, the outer consisting of a large basal cell which bears distally as a rule two antero-posterior branches; the inner simple, the outer furcate above its basal cell; the branches stout, slightly tapering, elongate, the inner erect, the outer divergent; its branchlets curving upward: the inner appendage consisting of a much smaller basal cell, rounded and bearing one or two short branchlets. Spores about $70 \times 5\,\mu$. Perithecia $125–155 \times 35–50\,\mu$. Total length to tip of perithecium $400–650\,\mu$; to insertion-cell $300–400\,\mu$. Appendages, longest about $600\,\mu$.

On *Tænodema* sp., Brit. Mus. No. 391. Ega, Amazon. On elytra and superior prothorax.

Laboulbenia tenuis nov. sp.

Perithecium relatively small and narrow, dull amber-yellow to brown, the upper half or more free from the receptacle, tapering somewhat distally, curved toward and partly across the appendages; the tip not well distinguished, broad, its distal margin often concave, the lips projecting slightly on either side, the lip-cells black except about the pore. Receptacle slender amber-yellow, becoming tinged with brown especially distally, strongly curved throughout, the concave side anterior. Insertion-cell black and thick, narrower than cells IV–V. Appendages as in *L. platystoma,* the basal cell of the outer appendage blackened externally, all the branches erect and lying across the tip of the perithecium which is bent toward them. The material on *Catoscopus* much larger and darker than that on *Miscelus*. Perithecia $90–130 \times 22–26\,\mu$. Total length to tip of perithecium $250–500\,\mu$; to insertion-cell $425–185\,\mu$. Greatest width $37–55\,\mu$. Appendages more than $200\,\mu$ (broken).

On *Miscelus Javanus* Klug., Hope Collection, No. 308, Java; on *Miscelus* sp., Paris Museum, Nos. 114 and 115, New Guinea; on *Catoscopus*? sp. Brit. Mus. No. 663, Assam, India. On the elytra and inferior surface.

Laboulbenia Thyreopteri nov. sp.

Perithecium nearly free, proportionately large, dull amber-brown, straight, narrower at the base, the inner margin slightly convex, the outer concave through the presence of a prominent subterminal hump, which is suffused with blackish brown, the suffusion often involving a fainter discoloration of the subbasal wall-cell below it; the tip small, prominent, and abruptly differentiated, blackish with broad hyaline lips. Receptacle slender, the basal cell black, opaque, mostly curved below, very slender; the subbasal cell broader, suffused with blackish, mostly verrucose or coarsely punctate, the remaining cells normal and concolorous with the perithecium. Insertion-cell thick and narrow. The outer appendage simple, its basal cell long, undifferentiated; the basal cell of the inner appendage shorter bearing a branch distally on either side, all the branches similar crowded, concolorous with the perithecium, erect, straight or bent slightly toward the perithecium, the inmost in contact with it. Spores 55 × 4 μ. Perithecia 140–175 × 14–25 μ. Total length to tip of perithecium 340–400 μ; to insertion-cell 250–270 μ. Appendages 120–140 μ.

On *Thyreopterus flavosignatus* Dej., Brit. Mus. No. 561, Port Natal, Africa. On *Thyreopterus* sp., Paris Museum, No. 125, Africa. On elytra.

Laboulbenia tibialis nov. sp.

Perithecium deeply suffused with blackish brown, somewhat inflated, the small tip rather abruptly distinguished. Receptacle stout, deeply suffused with blackish brown except cell I and the lower part of cell II, which are hyaline or nearly so, abruptly contrasting, and cell V which is yellowish; cells IV and V broad, the insertion-cell broad and in contact with the base of the perithecium. Appendages as in *L. rostellata* except that the inner is larger and longer than the outer without overlapping it at the base and the lower branch of the outer is simple. Perithecia 150–175 × 60–70 μ. Total length to tip of perithecium 300–325 μ; to insertion-cell 200–225 μ. Appendages exclusive of the branches, inner 100–120 μ, outer 85 μ.

On *Brachinus* sp., Eustis, Florida, October. On the legs.

Laboulbenia tortuosa nov. sp.

Perithecium with hardly more than the tip free, relatively small, externally suffused with smoky brown and concave through the presence of a well defined subterminal hunch, above which the somewhat pointed well defined outwardly oblique blackish-brown tip is abruptly differentiated, the lip-edges pale brown translucent. Receptacle very pale reddish or yellowish, variously bent, sometimes at right angles or at an angle of forty-five degrees above cell II; cells I and II straight or more frequently cell II curved strongly, while there is often a less pronounced curvature in the opposite direction immediately above it. Insertion-cell horizontal, about opposite the external hunch of the perithecium. Outer appendage consisting of a very large basal and somewhat broader subbasal cell, the two commonly as broad as or broader than any portion of the receptacle with which they are concolorous; the upper outer angle of both cells marked by the black insertion of a short simple branch, usually broken off, the subbasal cell surmounted by a small flattish cell which bears a simple terminal branch with blackened base like those developed laterally below it: the inner appendage consists of a very small basal cell which usually produces directly a pair of relatively large antheridia with inflated venters and brown necks. Perithecia $85 \times 27\ \mu$. Total length to tip of perithecium about $275\ \mu$. Appendage, to upper blackened septum $50\ \mu$, by $28\ \mu$ wide.

On *Pachyteles testaceus* Horn, U. S. National Museum, Arizona. Along the adjacent inferior margins of the thorax and prothorax, on left side.

Laboulbenia Trichognathi nov. sp.

Perithecium free, generally straight, long, narrow and of nearly equal diameter throughout to the base of the rather abruptly differentiated tip, (sometimes however shorter, stout and slightly inflated,) pale yellowish or becoming rather deep, evenly translucent smoky brown; the basal wall-cells forming a very short scarcely noticeable stalk; the tip obliquely black below the rather coarse and prominent hyaline lips. Receptacle generally very long and slender, pale yellowish, the basal cell tinged with brown; cells IV and V amber or often becoming wholly amber-brown or smoky brown; cells IV and V large, prominently marked by short transverse lines or patches which are less numerous and distinct on the other cells. Insertion-cell carried out free from the perithecium by the enlargement of cell V, well differentiated, black. Outer appendage consisting of a series of obliquely superposed cells three to ten in number,

the basal one subtriangular and blackish, the rest hyaline or yellowish, each producing distally and externally a single simple straight branch, slightly constricted at the three to four lower black septa; the distal portion without black septa, sometimes short, sometimes elongate and tapering. The inner appendage consists of a basal cell usually giving rise on either side to a series of superposed cells similar to those of the outer appendage, but mostly shorter and similarly branched; the three series in general partly united at least at the base, the basal cell in some cases bearing more than two such series so that a very dense tuft of branchlets results. Perithecia 165 × 55–350 × 90 μ, average 275 × 60 μ. Receptacle very variable. Total length to tip of perithecium 425–1480 μ; to insertion-cell 275–1260 μ. Appendages, longest 600 μ, average about 400 μ.

On *Trichognathus marginipennis* Latr., Hope Collection, No. 267, Columbia, Brit. Mus. No. 525, "Tamaz," S. America; on "*T. marginatus* Latr." Brit. Mus. No. 526, Brazil, Hope Collection, No. 266, "S. America"; on *Trichognathus* sp. indet., Paris Museum, Nos. 70, 71, and 135, Venezuela and "S. America." On all parts of host.

Laboulbenia triordinata nov. sp.

Perithecium usually wholly free from the receptacle, very variable, amber-brown or usually becoming almost black, generally elongate, often with the wall-cells showing a distinct spiral twist, the basal wall-cells forming a hyaline or less deeply suffused neck; the tip wholly black except the lip-edges, which may be translucent and more or less distinctly differentiated. Receptacle elongate or rather short, pale amber-brown or amber-yellow, gradually tapering from the base to the very broad distal portion, or more commonly cells I and II forming a slender stalk above which the rest of the receptacle expands abruptly, the unmodified triangular insertion-cell carried up and out free from the receptacle through the enlargement of cell V, the inner margin of which is mostly free. Outer appendage consisting of a series of about seven to ten obliquely superposed cells, each bearing distally and externally a single simple branch; the branches constricted at the first, second, and third septa, which are deeply blackened; the second less broadly, the first and second cells variably suffused with clear brown especially near the septa, the distal portion of the branch hyaline, tapering, its cells longer, the lower swollen below the septum: inner appendage consisting of a basal cell which gives rise on either side to a branch resembling the outer appendage often with fewer cells (sometimes only 3-celled) similarly branched,

except that the lower branchlet of each branch bears a single large terminal antheridium which becomes brown; the outer appendage and the two branches of the inner erect and close together or more or less strongly and irregularly divergent. Perithecia, average $200 \times 52\,\mu$ ($110–260 \times 45–60\,\mu$) including stalk. Total length to tip of perithecium $260–600\,\mu$; to insertion-cell $185–370\,\mu$; greatest width $65–100\,\mu$. Appendages $220–330\,\mu$.

On *Calophæna bifasciata* Oliv., Brit. Mus. No. 509, South America; on *Calophæna* sp., Brit. Mus. No. 512, Nanta, Amazon; on *Cordistes bicinctus* Dej., Hope Collection, No. 268, Columbia; on *Cordistes?* sp., U. S. National Museum, Central America; on *Helluomorpha melanaria* Reich., Brit. Mus. No. 527, Ega, Amazon.

Laboulbenia tuberculifera nov. sp.

Perithecium deeply suffused with smoky brown, free except the lower fifth; the tip not abruptly distinguished, nearly black, the distal margin somewhat oblique, mostly straight with an outer more or less ill defined tooth-like prominence; in general variable, the lip-cells not prominent. Receptacle rather long and slender, cell I quite hyaline below, distally tinged with deep brown and coarsely punctate; cell II tinged with brown and punctate below, otherwise nearly hyaline, except for the presence of a series of deep brown short tubercular transverse ridges on one side of cell IV and the basal cells of the perithecium which are deep brown, the rest subhyaline, cell IV bulging. Outer appendage simple, slender, the basal cell sometimes long and somewhat inflated: the inner appendage consisting of a small basal cell with a short branch on either side. Perithecia about $140 \times 50\,\mu$. Total length to tip of perithecium, average $340\,\mu$; to insertion-cell, average $225\,\mu$; greatest width $60\,\mu$. Appendages $225\,\mu$ (longest).

On *Serrimargo guttiger* Schaum., Brit. Mus. No. 558, Penang, East Indies. On base of elytra.

Laboulbenia uncinata nov. sp.

Pale yellowish, becoming tinged with pale reddish yellow. Perithecium more than one half free, stout, nearly oblong, the blackened lip-cells recurved externally through the rounded upgrowth of the inner distal portion of the perithecium which makes them almost lateral in position, the outer lip-cell often twice as long as the others and more prominently recurved, its projecting portion translucent, rounded. Receptacle

medium, normal. Appendages normal, rather short, several times branched, the cells rather short and somewhat rounded. Spores 50 × 3.5 μ. Perithecium (not including lip-cells) 120 × 62 μ. Total length to tip of perithecium 100–120 μ; to insertion-cell 72–92 μ. Appendages (longest) 40 μ.

On *Harpalus æneus* Fabr., Selenga, Siberia, Paris Mus. No. 12. At base of anterior legs.

Laboulbenia verrucosa nov. sp.

Perithecium becoming deeply suffused with smoky brown, straight, the line of demarcation between the subterminal and subbasal wall-cells indicated by a more or less well defined ridge forming a rather prominent external hunch in this region, above which the perithecium is abruptly contracted, almost at right angles in the type, below the rather narrow nearly erect tip, the lip-cells black below, with the broadly hyaline edges turned obliquely outward. Receptacle dirty yellow-brown, becoming more or less suffused with smoky brown, especially the two basal cells, and covered with irregular wart-like prominences which are more or less definitely arranged in transverse rows. Appendages of the "*L. flagellata*" type, the outer once to twice branched, the inner consisting of a smaller basal cell giving rise on either side to single branches which may be from once to three times branched; all the branches pale dirty yellowish with brown shades above the lower septa. Perithecia 150–170 × 45–50 μ. Total length to tip of perithecium 550–610 μ; to insertion-cell 430–480 μ. Appendages (longest) 400 μ.

On a Carabid allied to *Platynus*, Hope Coll. No. 342 (without label) and U. S. Nat. Museum, No. 7, Mt. Coffee, Liberia, Africa. Elytra.

PUBLICATIONS

OF THE

AMERICAN ACADEMY OF ARTS AND SCIENCES.

MEMOIRS. OLD SERIES, **Vols. I.–IV.; NEW SERIES, Vols. I.–XII.** 16 volumes, $10 each. Half volumes, $5 each. 25% discount to booksellers; 50% to members.

Vol. X.	Part II. *bis*	$1.75
" XI.	" I.	2.00
" XI.	" II. No. I.	3.00
" XI.	" III. " II.–III.	1.00
" XI.	" IV. " IV.	1.00
" XI.	" IV. " V.	.75
" XI.	" V. " VI.	.25
" XI.	" VI. " VII.	2.00
" XII.	No. I.	1.50
" XII.	" II.	2.00
" XII.	" III.	6.00
" XII.	" IV.	1.25

PROCEEDINGS. Vols. I.–XXXIV., $5 each. 25% discount to booksellers; 50% discount to members.

Complete sets of the MEMOIRS, 15 vols., for $112.50, to members, $60; of the PROCEEDINGS, 34 vols. for $129, to members, $68.

Proceedings of the American Academy of Arts and Sciences.

VOL. XXXV. NO. 20. — APRIL, 1900.

VIEW OF THE CARBONIFEROUS FAUNA OF THE NARRAGANSETT BASIN.

BY ALPHEUS S. PACKARD.

PALEONTOLOGICAL NOTES.

IV.* VIEW OF THE CARBONIFEROUS FAUNA OF THE NARRAGANSETT BASIN.

By A. S. Packard.

Received February 21, 1900. Presented March 14, 1900.

While the flora of the Narragansett coal basin is abundant, remains of about eighty-eight species of plants having been detected in the black carbonaceous shales and lighter sandstones, but few traces of animal life have been found, these being mostly the wings of cockroaches and other net-veined insects.

The age of these beds was originally supposed by the elder Hitchcock to be Lower Carboniferous, but from a collection from the black shales near the western edge of the Narragansett coal basin, at Providence and Pawtucket, in the Museum of Brown University, sent by us for examination by Lesquereux, he referred the beds to the Upper Carboniferous, stating in a letter to us :

"These specimens, taken together, are interesting, as indicating more than any other lot I have seen of fossil plants of Rhode Island, the stratigraphical relations of your coal strata to those of the upper part of the anthracite measures of Pennsylvania, where, even, I have not observed such a predominance of species of Odontopteris typically allied to those described by Fontaine and White from the Upper Carboniferous of Pennsylvania." †

Besides the fourteen species of insects and an arachnid described by Scudder ‡ from the plant beds of Rhode Island, we have previously noticed § the discovery of other fossil animals, viz., *Spirorbis carbonarius*,

* Paleontological notes I.–III. appeared in Proceedings Boston Society of Natural History, xxiv., 1889, pp. 209–216. See also Recent discoveries in the Carboniferous flora and fauna of Rhode Island (Amer. Journ. Sci., 3d Series, xxxvii., p. 411, 1889).

† Proceedings Boston Soc. Nat. Hist., xxiv., 1889, p. 214.

‡ Insect fauna of the Rhode Island coal field. Bulletin U. S. Geol. Survey, No. 101, 1893.

§ *L. c.*, p. 214.

the supposed impression of an Annelid, and the track either of a mollusc or worm. We now have to announce the discovery of additional animal remains and tracks detected by Mr. J. H. Clarke of Providence, who for nearly thirty years has industriously collected in this coal field. These comprise casts of a fresh-water bivalve, *Anthracomya arenacea*, small footprints, possibly those of a shrimp-like animal (*Protichnites carbonarius*), and an impression which seems to be rather worm-like than plant-like.

We will enumerate these forms in a way to give a conspectus of the animal life of the Narragansett coal basin, so far as known up to the present time.

Annelida.

Spirorbis carbonarius. Pawtucket plant beds. (Scholfield and Gorham) Proc. Bost. Soc. Nat. Hist., xxiv, 1889, p. 214.
Impression of an Annelid? Pawtucket plant bed. (Scholfield) Ibid., p. 215.

Impression of a plant or worm? This marking or impression was found by Mr. J. H. Clarke in a boulder of fine red shale at South Attleboro, Mass. Whether it is an impression of an aquatic plant or of a worm I am not sure, but am rather inclined to regard it as a worm-cast. It is serpentine, with from four to five curves, no two curves alike. In front it ends broadly, is pointed triangularly, tapering more at what appears to be the posterior end. Length 70 mm.; greatest breadth 4 mm.

Sections of worm holes. I am indebted to Mr. J. B. Woodworth for the opportunity of visiting with him an interesting quarry, one mile south of East Attleboro, in red and green shales and light conglomerates, the greenish shales showing distinct coarse ripple marks, rain-drops, and mud cracks, besides numerous sections of worm holes, perpendicular to the bedding. The worm holes are abundant, some eight or ten to the square inch, and varying in size from $\frac{1}{16}$ to $\frac{1}{8}$ of an inch in diameter. The round deep holes had been excavated in a fine mud, and then, after the worms had left them or died, silted up with fine sand. If the worms which made these deep holes were fresh-water forms they were much larger than any Nais-like Oligochetes known to us at the present day, and were possibly therefore marine.

Mollusca.

Anthracomya arenacea (Dawson) Hind. (Fig. 1, A, B, C.) These occurred in a small boulder of fine black shale found by Mr. Clarke at

Valley Falls. In this specimen there were about a dozen casts of valves of old and partially grown shells with the shape and markings in some cases well preserved owing to the fineness of the shale. Another specimen showing well the shape of the valves was detected in the black shaly plant-beds enclosing a vein of coal just north of Silver Spring, East Providence, by Prof. F. P. Gorham, associated with the verticillate leaves apparently of Calamites. In these specimens the valves are elliptical, long, narrow, pod-like, the anterior end but little larger and rounder than the posterior end. The umbones are situated at or between the anterior $\frac{1}{3}$ and $\frac{1}{4}$ of the shell. There are about twenty-five fine lines of growth. The fully grown specimens are narrower than the young and the anterior is but little larger and rounder than the posterior end. Size and proportions of the largest examples: length 22 mm., breadth 9 mm., being about $2\frac{1}{2}$ times as long as wide. Length of the East Providence example, 17 mm.; breadth, 9 mm. In this example the umbones are situated near the anterior fourth of the valve. The young in the loose boulder were 10 mm. in length, 5 mm. in width, or one-half as wide as long, with numerous fine lines of growth.

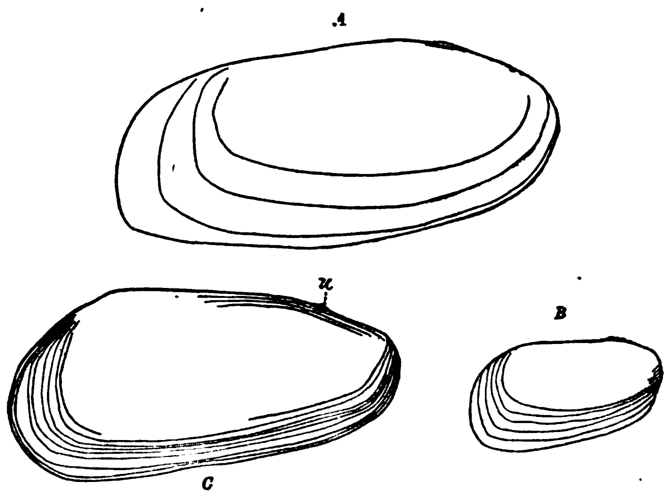

FIGURE 1. — *Anthracomya arenacea*. $\times\ 2\frac{2}{3}$. *u*, umbo.

The Rhode Island specimens present no differences from the description and figures of Dawson (Acadian Geology, 3d edit., p. 205). It is an entirely different species from *Naiadites elongatus* and *laevis* Dawson, of

which I have examples, kindly sent me by the late Sir J. W. Dawson. It is also different from any British species figured by Wheelton Hind in his elaborate monograph. Desirous of comparing our specimens with types from Nova Scotia, I applied to Dr. G. M. Dawson, Director of the Geological Survey of Canada, who very kindly sent me specimens from the museum of the Survey, labelled in Sir J. W. Dawson's own handwriting, from Sydney, C. B.. I can see no specific differences, although the Sydney examples are casts in a rather coarse micaceous sandstone, a less favorable medium for the preservation of specific marks; but the general shape and proportions of the valves are the same. The Sydney examples are small specimens from 8 to 14 mm. in length; each end is much alike, and the beaks are plainly situated at the anterior $\frac{1}{4}$–$\frac{1}{5}$ of the shell; in the largest one at the anterior third. In Fig. 1, *A* represents a large, and *B* a much smaller specimen in the pebble found by Mr. Clark, and *C* a specimen intermediate in size found in place by Prof. Gorham. All are drawn to the same scale and are enlarged.

Track of a gastropod mollusc? Pawtucket plant beds. (Scholfield) Proc. Bost. Soc. Nat. Hist., xxiv., p. 215. This track is, of course, doubtful, and might have been made by a worm.

MEROSTOMATA.

Protichnites narragansettensis, n. sp. This name is given to a new kind of track discovered in a pebble of dark arenaceous shale taken from a kame in north Providence by one of my class, Mr. H. H. Mason. It is allied to and evidently made by a species of perhaps the same group as made the tracks described as *Protichnites octonotatus* Owen, and *P. logananus* Marsh from the Cambrian. Description and figures are reserved for a future occasion.

CRUSTACEA.

Remains of a Crustacean? Three fragments of the remains of what appears to be a macrurous crustacean were found in the black shales of Valley Falls by Mr. Clarke, associated with the leaves of Calamites. The better preserved fragment is square at the base, with one side produced above and ending squarely; the lower corners are truncated. On the lower edge of this fragment is a distinct raised boss or tubercle, while the two other fragments are not thus marked. The plates remind one of the epimerum of a shrimp, which is wider on the ventral edge than above. The surface is polished but has not the markings of a Pandalus. The surface is however marked with very fine irregular raised lines

passing across the surface. The edge is margined somewhat as in Pandalus.

I was at a loss to what group to refer these remains, but on showing them to Prof. C. E. Beecher he suggested that they might be crustacean, and I am inclined to agree with him. The sides of the segments of Acanthotelson are no wider ventrally than tergally; there is also no close resemblance to the segments of Palæocaris, both being from the Carboniferous beds of Mazon Creek, Illinois. It is possible that they may belong to some true shrimp such as Anthrapalæmon or other macruran of that period.

Ostrakichnites carbonarius (*Protichnites carbonarius*) Dawson, Acadian Geology 3d edit., 1878, p. 55. Fig. 9, *a*.

Dawson describes and figures certain tracks from the millstone grit formation at McKay's Head in Nova Scotia which he refers to Protichnites and which he supposes to have been made by a Limulus-like animal.

Somewhat similar but much less regularly arranged tracks occurred in a boulder of fine red shale found in a stone wall at South Attleboro, kindly given me by Mr. J. H. Clarke. The tracks were associated with mud cracks, raindrops, and the worm-like impression already mentioned.

They are of the same size as those figured by Dawson, but are not so regularly arranged, being much more scattered, and with no median linear tail-mark. Yet the individual impressions are of the same shape and size, and so like those of Dawson's Protichnites that they were apparently made by the same kind of animal and could perhaps have been made by the extremities of the feet of a small shrimp-like creature.

The impressions are in sets of three, each of which is round in front, deep and succeeded behind by a shallow faint furrow, showing where the tip of the foot or spine of the hinder feet had trailed over the mud, before the final impress of the feet was made. The three impressions are not arranged in a straight line, but in a slightly curved line, showing that the middle spine or claw was longer than the lateral ones. In some cases there are single impressions forming two series about 8 mm. apart, but with no tail-mark between.

The Protichnites tracks figured by Dawson, could not have been made by a full grown Euproöps or Prestwichia, and it should be observed that the set of three prints is quite different from the long oblique crescentic tracks made by the hind cephalic legs of Limulus. The tracks might as well have been made by the crustaceans Gampsonychus, Anthrapalæmon,

or Acanthotelson, whose legs end in a sharp point. As the tracks were evidently not made by any merostome, we have thought it well to refer these trails to a new genus, for which we propose the name *Ostrakichnites*, although we are not fully persuaded that it is worth while to bestow names on these tracks, except for convenience of reference.

ARACHNIDA.

Anthracomartus woodruffi Scudd. Pawtucket plant beds. (Rev. E. F. Clark.)

INSECTA.

Mylacris packardii Scudd. Bristol plant beds. (Rev. E. F. Clark.)
Etoblattina illustris Scudd. Pawtucket plant beds. (J. H. Clark.)
" *sp.* Silver Spring, East Providence. (H. Scholfield.)
" *clarkii* Scudd. Pawtucket plant beds. (Rev. E. F. Clark.)
" *scholfieldii* Scudd. East Providence plant beds. (H. Scholfield.)
" *sp.* Fenner's Ledge, Cranston, near Providence. (F. P. Gorham and H. Scholfield).
" *gorhami* Scudd. Pawtucket plant beds. (F. P. Gorham.)
" *exilis* Scudd. From a boulder near Kettle Point, East Providence. (H. Scholfield.)
" *sp.* Pawtucket plant beds. (H. Scholfield.)
" *reliqua.* Pawtucket plant beds. (F. P. Gorham.)
Gerablattina scapularis Scudd. Pawtucket plant beds. (H. Scholfield.)
" *fraterna* Scudd. Silver Spring, East Providence. (H. Scholfield.)
Rhaphidiopsis diversipenna Scudd. Cranston plant beds. (Rev. E. F. Clark.)
Paralogus æschnoides Scudd. Silver Spring, East Providence. (F. P. Gorham.)

The presence of the Spirorbis and of the tracks of two marine Arthropods suggest that the Rhode Island plant-beds, even if in general of fresh water origin, were deposited where the sea had access to them. The presence of these marine fossils, with the fresh water naiad, *Anthracomya arenacea*, strongly suggests that the horizon of the black shales of Providence and also of the red and greenish beds of Attleboro, Mass., belong to the same horizon as those of the South Joggins of Nova Scotia, which is Upper Carboniferous, the rocks there consisting of sandstones and dark carbonaceous shales, frequently becoming reddish. The South Joggins shales also contain the remains of Anthrapalæmon, which should be looked for in the Narragansett coal measures. Thus far, then, the animal remains confirm Lesquereux's reference of the dark plant-beds to the Upper Coal Measures.

These beds also appear to be higher in the series than the Middle Carboniferous Mazon Creek beds of Illinois which contain a larger

number of marine animals, viz., Belinuridæ (Euproöps, Prestwichia and Belinurus), besides Anthrapalæmon and Acanthotelson, together with the impressions of marine annelid worms.

It should be observed that the black plant-beds of Providence on the western side of Providence Bay, which dip southeastward at an angle of 45°–50°, extend over to the arkose conglomerates on the western edge of the basin, which are very highly inclined and dip westwards. The thickness of the plant-beds, unless much folded, appears to be over a mile. The exact relations of the plant-beds on the eastern side of Providence to the arkose conglomerates we have thus far been unable to definitely determine.*

BROWN UNIVERSITY.

* Since reading this proof I have, at a point about half a mile north of Natick, on the western edge of the coal basin, seen the gradual passage of the carboniferous shales into the arkose.

PUBLICATIONS

OF THE

AMERICAN ACADEMY OF ARTS AND SCIENCES.

MEMOIRS. Old Series, Vols. I.–IV.; New Series, Vols. I.–XII. 16 volumes, $10 each. Half volumes, $5 each. 25% discount to booksellers; 50% to members.

Vol. X.	Part II. *bis*	$1.75
" XI.	" I.	2.00
" XI.	" II. No. I.	3.00
" XI.	" III. " II.–III.	1.00
" XI.	" IV. " IV.	1.00
" XI.	" IV. " V.	.75
" XI.	" V. " VI.	.25
" XI.	" VI. " VII.	2.00
" XII.	No. I.	1.50
" XII.	" II.	2.00
" XII.	" III.	6.00
" XII.	" IV.	1.25

PROCEEDINGS. Vols. I.–XXXIV., $5 each. 25% discount to booksellers; 50% discount to members.

Complete sets of the Memoirs, 15 vols., for $112.50, to members, $60; of the Proceedings, 34 vols. for $129, to members, $68.

Proceedings of the American Academy of Arts and Sciences.

Vol. XXXV. No. 21. — April, 1900.

CONTRIBUTIONS FROM THE CRYPTOGAMIC LABORATORY OF HARVARD UNIVERSITY. — XLII.

PRELIMINARY DIAGNOSES OF NEW SPECIES OF LABOULBENIACEÆ. — II.

By Roland Thaxter.

CONTRIBUTIONS FROM THE CRYPTOGAMIC LABORATORY OF HARVARD UNIVERSITY. — XLII.

PRELIMINARY DIAGNOSES OF NEW SPECIES OF LABOULBENIACEÆ. — 2.

BY ROLAND THAXTER.

Received March 19, 1900; Presented April 11, 1900.

Dimorphomyces Myrmedoniae nov. sp.

Male individual tinged with smoky brown, relatively small, similar to those of the other species, except that the neck of the antheridium is proportionately much shorter, its base inflated, its distal portion short and attenuated; the distal cell of the receptacle large, distally very thick-walled, the thickened portion undergoing a gelatinous degeneration. Total length to tip of antheridium, including foot, 65 μ, to tip of sterile portion 40 μ. Antheridium 38 μ long, the venter 25×14 μ.

Female individual relatively large, tinged with smoky brown, the sterile part of the receptacle terminated by a blunt distal cell, subtended by a blackened septum, the distal portion of which is thick walled and often swollen or disappearing through gelatinous degeneration; the fertile portion resembling that of the other species in general structure but developed almost at right angles to the axis of the sterile part on one side only, as in *D. Thleoporae*, very long and nearly isodiametric throughout; the perithecia from two to five in number and the appendages from three to six, alternating as a rule, the two series diverging slightly from opposite sides, the subtending cells relatively large and slightly oblique in reference to the marginal portion, so that their size appears to be greater when viewed on one side than on the other. Perithecium rather long and slender, nearly straight, stouter in small individuals and somewhat inflated; the tip blunt or nearly truncate; tinged with smoky brown, borne on a short divergent stalk-cell (hardly visible), from which it bends abruptly upward. Appendages relatively large, consisting of two superposed cells constricted at the septa, the basal one longer, distally more deeply suffused, the upper distally suffused and modified like the

corresponding portion of the sterile portion of the receptacle. Spores about 20 × 3 μ. Perithecia in well developed individuals 100 × 18 μ. Lateral portion of receptacle 75 × 20 μ, the sterile portion 60 μ. Appendages about 58 × 13 μ.

On *Myrmedonia flavicornis* Fauv., British Museum (Biologia Coll.), No. 766, Guatemala.

Dimorphomyces Thleoporae nov. sp.

Male individual much as in *D. muticus*, the receptacle ending in a short blackened cell, bluntly rounded or nearly truncate. Total length to tip of antheridium 66 μ, to tip of sterile cell 37 μ.

Female individual. Structure of the receptacle like that of the other species, but only developed on one side of the median sterile portion, which consists of three cells like that of the male individual and is black tipped. The appendages and perithecia arising as in the other species, the latter nearly symmetrically fusiform, bluntly rounded at the tip, tinged with smoky brown, the tip undifferentiated, the appendages (broken) relatively large and simple. Perithecia (not quite mature) 50 × 14 μ. Foot to end of lateral portion 50 μ. Total length to tip of perithecium 80 μ.

On *Thleopora corticalis* Gz., Paris Museum, No. 297, Santa Anna, Madeira. On inferior surface of abdomen.

Dimeromyces pinnatus nov. sp.

Male individual consisting of a basal cell more than twice as long as broad, the axis above of eight or nine cells separated by horizontal septa, all but the lowest and the terminal cell separating a small cell on one side which forms the base of an antheridium or of a sterile appendage, the two organs diverging slightly from one another so as to form two vertical rows. Antheridium compound, short and stout, the venter abruptly distinguished from the stout neck, the base of which is slightly enlarged and purplish brown, the distal part tapering very slightly, the apex blunt. Appendages consisting typically of six cells, including the basal cell, constricted at the dark septa, the distal cells suffused with brownish, the terminal one larger, longer, and more or less vesicular, the thick walls tending to gelatinous degeneration. Total length of receptacle 100 × 12 μ. Antheridia 35 × 12 μ. Appendages 50 × 7 μ.

Female individual. Basal cell large and stout, the cells above it about twenty in number, greatly flattened, the septa horizontal, a few of the

lower cells having appendages on only one side or none, the rest bearing them on both sides. Appendages simple, consisting of from five to seven cells including the basal cell, constricted at the dark septa, the terminal cell hyaline and much larger, as in the male; the rest, except the basal one, purplish or the upper one tinged with brown. Perithecia one to three in number, mostly rather slender, slightly curved outward; the stalk portion about half as long as the remainder, which is purplish brown, deeper distally; the tip well distinguished when not distended by spores, consisting of a basal portion larger and slightly inflated and a distal one, formed by the lip-cells, abruptly distinguished, its external margins generally symmetrically divergent, the four cells nearly equal and symmetrical and ending distally in a corresponding number of papillæ about the pore. Perithecia including stalk, 125 × 20 μ. Receptacle 190–225 × 28 μ, not including basal cells of appendages. Appendages 55 × 8 μ.

On *Ardistomis* sp., Hope Collection, No. 296. No locality, but probably Mexico or South America. At base of elytra and on leg.

Dimeromyces nanomasculus nov. sp.

Male individual very minute, consisting of three superposed cells, the upper bearing a terminal two-celled appendage with dark septa, the subbasal cell giving rise to a single antheridium like that of *D. pinnatus*, smaller, the neck usually abruptly turned to one side. Total length to tip of appendage 35 μ; the antheridium about 15 × 5 μ.

Female individual resembling that of *D. pinnatus* in general structure, the basal cell large and long, narrower below; the cells above about ten to fifteen in number, usually roundish; the appendages mostly five-celled above their basal cell, variably suffused with brown, the septa dark, sometimes curved or almost hooked distally, the distal cell not conspicuously enlarged becoming brownish; the subterminal cell of the single terminal appendage examined producing a blackish-brown, lateral, irregular, spine-like outgrowth. Perithecium straight, more commonly solitary near the tip, brownish yellow to dark brown, not at all distinguished from the stalk, which is hyaline only at its narrow base, the hyaline tip abruptly distinguished by a slight subtending ridge, its margins usually converging symmetrically to the truncate or blunt apex. Spores about 45 × 3 μ. Perithecia, including stalk, 100–120 × 20–24 μ. Appendages longer 60 × 6 μ. Total length to tip of perithecium 245–285 × about 22 μ.

On *Ardistomis viridis* Say, Cocoanut Grove, Florida. November. On *A. educta* Bates, British Museum (Biologia Collection), No. 676.

MONOICOMYCES nov. genus.

Receptacle consisting of a basal and subbasal cell, above which it terminates in a small two-celled sterile portion, the terminal cell of which may or may not be in the form of a short appendage; the subbasal cell giving rise to from one to several fertile branches, the habit becoming thus unilateral, bilateral or subverticillate in different species. The fertile branches consisting of from one to several cells in different species, the terminal cell of each branch normally giving rise to a stalked perithecium and a stalked antheridium; the remainder, if there are more than one, appendiculate on the upper side, rarely (abnormally?) producing an additional antheridium. Antheridium of the compound type, consisting of a stalk composed of a pair of cells, the antheridium proper consisting of certain basal cells, two tiers of peripheral cells, which surround (not on all sides?) numerous antheridial cells and a cavity above them, and three or four terminal cells, which appear to surround an opening through which the antherozoids are discharged, and which subsequently grow upward, forming terminal simple appendages of irregular length.

Monoicomyces Homalotae nov. sp.

Receptacle consisting of very small hyaline basal and subbasal cells surmounted by a distal portion, very much as in Dimorphomyces, which is blackish brown, the lower cell larger and distally inflated. Fertile branches normally two, when the individual is bilaterally symmetrical, rarely three, consisting of a single cell which bears distally an antheridium from its outer and a perithecium from its inner angle. Perithecium amber brown slightly asymmetrical, relatively very large, short and stout, the lower half greatly inflated, generally more so on the outer than the inner side, distally conical, the small tip not distinguished, usually abruptly truncate, the stalk-cell hyaline, narrowing to its base. Antheridium borne on a pair of rather short stalk-cells, the basal cells somewhat smaller and angular, forming part of the wall around the antheridial cells, the wall cells somewhat smaller than the basal cells, but large and distinct, the terminal cells apparently four in number, later forming stout finger-like upgrowths of unequal length. Spores about $35 \times 3\,\mu$. Perithecia including basal cells $100–120 \times 30–35\,\mu$, the stalk-cell $35–40\,\mu$. Antheridia including stalk-cells (not the terminal projections) $70–80 \times 30–35\,\mu$. Sterile part of receptacle about $70\,\mu$.

On *Homalota putrescens* Woll., British Museum, No. 412, Azores. On inferior surface of abdomen.

Monoicomyces Brittanicus nov. sp.

Nearly or quite hyaline. General structure as in *M. Homalotæ*, the sterile portion of the receptacle small and inconspicuous, the terminal cell in the form of a short hyaline simple appendage. Fertile branches consisting of a single cell bearing the antheridium and perithecium as in *M. Homalotæ.* Perithecium rather long-stalked, slightly asymmetrical or bent, the base inflated, tapering gradually to the blunt undifferentiated tip. Antheridium borne on a pair of rather long stalk-cells, the basal cells almost exactly similar to them and distally not enclosing any portion of the antheridial cavity, the wall cells well developed, the cavity within them relatively small, the terminal cells growing up into generally stout finger-like processes which may extend above the tip of the perithecium. Perithecium, including basal cells, 90 × 30 μ. Antheridia to base of terminal projections 80 × 20 μ.

On *Homalota insecta* Thom., British Museum, No. 454, Hammersmith, England. On superior surface of abdomen.

Monoicomyces St. Helenae nov. sp.

Superficially resembling Compsomyces in general habit. Pale yellowish or straw colored. Receptacle consisting of a triangular basal and a squarish or roundish subbasal cell which bears a small distal cell with a short terminal appendage separated from it by a constricted blackish septum; two to four branches arising from the subbasal cell, normally fertile and consisting of from two to five, usually three, superposed cells which are commonly somewhat inflated distally, more so on one side, an upgrowth from which becomes separated so as to form a prominent small cell lying close against the base of the axis-cell next above and is simple or longitudinally divided; in the former case bearing one, in the latter a pair of peculiar short appendages from which they are separated by a conspicuously blackened septum; the basal cell of this appendage usually similarly blackened externally, as is the base of the cell above it, which is usually characteristically geniculate, its terminal portion erect suffused with brown or hyaline, and either terminating the appendage or followed by two or three hyaline cells. Perithecium symmetrically inflated slightly distinguished from the basal cells, the tip small straight truncate tapering but slightly and abruptly distinguished. The antheridium relatively small, its stalk and basal cells about equal, the antheridium proper about as large as the basal part and hardly broader, its terminal cells developing as in the other species to long flexuous hyaline upgrowths. Spores

38 × 3.5 μ. Perithecia 100–120 × 40–48 μ. The stalk 34–50 × 25–27 μ. Appendages of fertile branch 50–90 × 5 μ. Sterile part of receptacle 50–50 μ. Greatest length to tip of perithecium 250–435 μ.

On *Oxytelus alutaceifrons* Woll., British Museum, No. 411, Island of St. Helena. On abdomen and elytra.

Monoicomyces invisibilis nov. sp.

Hyaline. Basal cell of receptacle small subtriangular, the subbasal cell rather long and narrow, bearing terminally a distally rounded cell from which it is separated by an oblique septum and which is surmounted by a short simple cylindrical appendage ; the fertile branch developed on one side only, not distinguished from the receptacle and its appendage, consisting of two or three obliquely superposed cells extending obliquely upward in a divergent series, the terminal cell bearing a perithecium and antheridium in the usual relative positions, the subterminal cell sometimes apparently producing a second antheridium instead of the simple appendage which terminates the lower cell of the series. Perithecium borne on a rather short stout stalk-cell, its inflated basal half not distinguished from the flattened basal cells, its slender distal half abruptly distinguished. Antheridium apparently similar in general to that of the other species, its detailed structure not recognizable in the types. Perithecia 84 × 30 μ. The stalk-cell 20 × 10 μ. Receptacle, sterile part, about 40 μ. Total length to tip of perithecium 110–140 μ.

On *Homalota putrescens* Woll., British Museum, No. 412, Azores.

POLYASCOMYCES nov. genus.

Receptacle consisting of two superposed cells, the upper bearing a perithecium laterally and an appendage terminally. Appendage consisting of a series of superposed flattened cells, surmounted by a dome shaped portion which is not persistent (a compound antheridium ?). Perithecium with a distinct stalk-cell and well developed basal cells, the supporting cell and the lower wall cells forming a broad base the upper surface of which forms a broad ascigerous area, the asci arising from great numbers of ascigerous cells.

It has not been possible from the material available to determine the exact nature of the antheridium in this remarkable genus. The terminal dome shaped portion of the appendage appears to consist originally of several cells, but whether it constitutes the whole of the antheridium or whether the latter is represented in part or wholly by the curious cells

below it, was not shown by the material. The multiplication of ascigerous cells of which there are not less and probably more than thirty-six, distinguishes it from all other known genera.

Polyascomyces Trichophyæ nov. sp.

Pale dirty brownish. Perithecium broadest in the ascigerous zone, tapering thence to the distinctly differentiated neck-like tip, the subterminal wall cells enlarged distally, externally and laterally, the resultant rounded protuberances forming a ridge about the tip just above its middle, the distal portion, formed by the lip-cells, of which that on the right is slightly longer than the rest, broad blunt brownish, the other three somewhat shorter terminating in narrow blunt extremities which lie on three sides of the first. The stalk-cell similar to and lying beside the subbasal cell of the receptacle to which it is united throughout, its base being in contact with the distal end of the basal cell, while from its distal end the large basal cells of the receptacle curve abruptly outward and upward. The appendage consisting of from three to six flat superposed darker brown cells, constricted at the septa, looking as if they had been made irregular by crushing, the terminal portion (antheridium ?) blunt, slightly longer than broad, with evidences of lateral apertures. Spores $28 \times 2.5\ \mu$. Perithecia $175 \times 50–65\ \mu$. Basal cells $40–48 \times 30\ \mu$. Stalk $38\ \mu$. Receptacle $70\ \mu$. Appendage $48–60 \times 20–24\ \mu$.

On *Trichophya pilicornis* Gyll., British Museum, No. 453, Farnham, England. On superior surface of abdomen.

Cantharomyces Platystethi nov. sp.

Yellowish with a brownish tinge. Receptacle consisting of a small basal cell and a subbasal cell more than twice as large, bearing the perithecium and appendage. Perithecium borne on a rather long stalk-cell, the basal cells continuous with its main body which is inflated below, conical above, the narrow apex truncate or bluntly rounded. The appendage large, its subbasal cell nearly twice as long as the basal, bearing the very small antheridium which forms a short cellular margin below its upper inner angle and apparently consists of not more than ten cells; the subbasal cell terminated by an irregular series of small cells which appear to produce a tuft of branches distally, and from which it may sometimes be separated by a third cell similar to it. Perithecia $80–86 \times 35\ \mu$. The stalk-cell $55 \times 20\ \mu$. Receptacle $50–70 \times 28\ \mu$. Appendages $140–170\ \mu$.

On abdomen of *Platystethus cornutus* Grav., British Museum, No. 449, Kilburn, England.

Eucantharomyces Diaphori nov. sp.

Pale straw colored. Perithecium rather short and stout, its basal cells small, slightly and usually symmetrically inflated; tapering from about the middle to the broad blunt slightly asymmetrical tip, which is subtended below the free lips, on the inner side, by the flat trichophoric cell, just above which arises a very slender recurved rigid appendage (not cellular) about 8–9 μ long. Receptacle rather short and stout, the subbasal (anterior) cell somewhat stouter than the basal, the two together somewhat larger than the short stalk-cell of the perithecium. Appendage relatively large, its basal cell short subtriangular, the upper and lower septa oblique, the subbasal cell slightly longer than broad, its upper two thirds bordered by the marginal cell which terminates in a slender stiff straight spine-like process about 11–12 μ long and slightly divergent; the antheridial cells in five rows of five, four, three, three, and two cells respectively; a single additional cell sometimes persisting above the antheridial cavity; the discharge tube bent outward and slightly upward, the tip bluntly conical with a slight basal enlargement. Spores 40 × 3.5 μ. Perithecia 120 × 30 μ. The stalk-cell 30 × 18 μ. Appendage 70 μ long, the antheridium 28 × 21 μ. Receptacle 45 × 24 μ. Total length to tip of perithecium 180 μ.

On *Diaphorus tenuicornis* Chaud., British Museum (Biologia Coll.), No. 714. Oaxaca, Mexico. On mid-elytron.

Eucantharomyces spinosus nov. sp.

Perithecium straw colored, rather stout, inflated, tapering to the broad asymmetrical tip which is slightly sulcate; the outer lips often larger than the inner, the latter bordered or subtended by the more deeply colored trichophoric cell which, in mature specimens, is not very conspicuous; the stalk-cell rather short. Receptacle short, the cells nearly equal. Appendage much as in *E. Diaphori*, more slender, the marginal cell extending nearly to the base of the subbasal cell, distinctly enlarged below a terminal spine-like process, which is usually nearly erect; the antheridial cells in three rows of five, three (relatively large) and one to two cells respectively, the discharge tube large and broad, nearly truncate, bent abruptly upward from the base. Spores 35–40 × 3.5–4 μ. Perithecia 138 × 41 μ. Appendage 70 × 14 μ, the antheridium 35 ×

$16\,\mu$. Receptacle $50 \times 20\,\mu$. Total length to tip of perithecium 190–207 μ.

On *Drypta* sp., Paris Museum, No. 80. Java. On elytron.

Eucantharomyces Euprocti nov. sp.

Perithecium straw colored to pale amber brown, slightly asymmetrical, somewhat inflated below; the upper half tapering gradually to the blunt asymmetrical apex which is subtended on the inner side by the rounded flat darker amber brownish trichophoric cell which may extend slightly beyond the lip-edges, simulating a lip-cell: the outline of the mature perithecium becoming more or less corrugated through the appearance of three to five rather broadly rounded successive elevations, corresponding to the distal and basal septa of the two lower tiers of wall cells and to a median protrusion of these cells where five are present; stalk-cell becoming slender, mostly slightly shorter than the receptacle; the basal cells small. Receptacle relatively rather long, the cells nearly equal. Appendage generally longer than the receptacle, its basal and subbasal cells nearly equal; antheridial cells in three rows of five, three, and two cells each, the marginal cell bluntly rounded above and extending nearly to the base of the subbasal cell; the discharge-tube large, bent outward or obliquely upward. Spores $50 \times 4.5\,\mu$. Perithecia $160–170 \times 48\,\mu$, stalk-cell $70 \times 15\,\mu$. Receptacle $85–90 \times 25–30\,\mu$. Appendage $110\,\mu$, antheridium $41 \times 22\,\mu$, the discharge-tube $30\,\mu$. Total length to tip of perithecium $310\,\mu$.

On *Euproctus quadrinus* Bates, British Museum (Biologia Coll.), No. 731. Volcan de Chiriqui, Panama.

Eucantharomyces Casnoniae nov. sp.

Perithecium relatively large, rather long, often slender, inflated below, tapering to the relatively narrow blunt apex; its outline corrugated through the presence of from seven to eleven elevations varying in prominence, the trichophoric cell simulating a lip-cell, the basal cells elongated and as long or nearly as long as the rather stout stalk-cell. Receptacle relatively small. The basal and subbasal cells of the appendage relatively small and stout, nearly equal, or the latter somewhat smaller, the marginal cell bordering its upper half and distally prominent, partly free and slightly inflated, ending in a short spine-like tip; the antheridium consisting of three rows of nine, seven and five cells respectively, the discharge-tube relatively short and stout, bent upward

and over the prominent tip of the marginal cell. Spores 45 × 3.5 μ. Perithecia 240–260 × 45–62 μ, stalk-cell 75–80 × 20–28 μ, basal cells 75–100 × 25–30 μ. Receptacle 55–65 × 27 μ. Appendage 85–103 μ, the antheridium 50–60 × 24–28 μ. Total length to tip of perithecium 375–450 μ.

On *Casnonia subdistincta* Chaud., British Museum (Biologia Coll.), No. 704. Cordova, Mexico.

Eucantharomyces Callidæ nov. sp.

Perithecium rather narrow, slightly inflated, tapering from about the middle to the blunt tip which is rather abruptly distinguished externally, sometimes bent outward, its distal margin outwardly oblique; the relatively small trichophoric cell simulating a lip-cell, projecting slightly beyond the latter externally, but not abruptly distinguished on its inner side; the outline of the perithecium becoming inconspicuously corrugated through the presence of sometimes as many as eleven successive elevations; the basal cells elongated, the base of one of the outer external to the stalk-cell from which it is separated by an oblique septum longer than the width of the stalk-cell, which is narrower below and about equal to the basal cells in length or somewhat shorter. Receptacle symmetrically sulcate distally, rather long, the two cells nearly equal. Appendage rather long, its basal cell extending downward and lying external to the upper half of the subbasal cell of the receptacle; the subbasal cell more than twice as long as broad, the marginal cell reaching to its base and distally prominent. Antheridium relatively small, the antheridial cells in three rows of five, four, and three cells respectively, the discharge-tube rather short and stout, erect or bent but slightly. Spores 40 × 4 μ. Perithecia 230–265 × 50 μ, basal cells 120 μ, stalk-cell 103 μ. Receptacle 100–120 μ. Appendage 120–125 μ, antheridium 25 × 38 μ. Total length to tip of perithecium average 325 μ.

On *Callida* sp., Paris Museum, No. 68. Venezuela.

Eucantharomyces Africanus nov. sp.

Very similar to *E. Callidæ*. Amber brown. Perithecium large subfusiform, the margins generally indistinctly corrugated, sometimes marked by fine transverse striations which may be wholly absent, the tip relatively small and rather abruptly distinguished, the trichophoric cell well defined, projecting beyond the lip-cells so that the apex usually appears oblique asymmetrical and slightly sulcate; the basal cells somewhat

shorter than the stalk-cell, their lower septa nearly equal and symmetrical, both slightly oblique. Receptacle of medium size, the basal cell distally enlarged. Appendage short, the two basal cells rather small and nearly equal in length, consisting of three rows of six, four, and four cells respectively, the discharge-tube slightly curved, abruptly nearly erect, distally somewhat narrower and conical when young, the marginal cell extending nearly to the base of the subbasal cell. Perithecia 275–325 × 45–50 μ, the stalk-cell 100–130 μ, the basal cells 75–100 μ. Receptacle 100 × 26 μ. Appendage 100 μ. Antheridium 45 × 21 μ, the discharge tube 21 μ. Total length to tip of perithecium 575–600 μ.

On *Callida Natalensis* Hope, Hope Coll. No. 274, Natal, Africa. On *Callida* sp., Brit. Museum, No. 550, Angola, Africa. On elytra.

Eucantharomyces Catascopi nov. sp.

Straw colored becoming pale amber brown. Perithecium elongate tapering but slightly toward the tip or becoming distally swollen through the pressure of the spore mass, the margins corrugated through the presence of sometimes as many as seventeen or even more prominences, which are mostly well defined, especially the distal one of the series, above which the slightly bent tip is abruptly distinguished, its distal margin straight oblique, the lip-cells extending just beyond the small darker trichophoric cell; basal-cells very much elongated and often corrugated through the presence of six or more elevations corresponding to those of the perithecial wall-cells; the stalk-cell rather stout much shorter than the basal cells, from which it is separated by an outer very oblique and an inner short nearly horizontal septum. Receptacle relatively small, the basal cell longer than the subbasal cell, distally enlarged so that it almost coincides with the base of the stalk-cell, which is thus hardly in contact with the subbasal cell from which it was originally derived. The basal cell of the appendage somewhat smaller than the subbasal cell, the marginal cell bulging outward slightly distally and extending almost to the base of the subbasal cell. Antheridial cells in five rows of eight, seven, six, five, and four cells or the four inner rows somewhat variable. Spores 50 × 4.5 μ. Perithecia 400–475 × 60–70 μ, the stalk-cell 140–200 × 35–40 μ, the basal cells 200–240 μ. Receptacle 100–110 × 38 μ. Appendage 120 μ; antheridium 60 × 32 μ. Total length 680–950 μ.

On *Catascopus* sp., Paris Museum, No. 117. Îles des Moluques. On the margin of the right elytron.

Dichomyces Javanus nov. sp.

Perithecium as long or longer than the receptacle, clear dark reddish brown, translucent, straight or slightly curved, rather slender, of about the same diameter throughout, the tip usually abruptly distinguished, and more or less conspicuously bent to one side, tapering but little to the rather broad blunt undifferentiated apex. Receptacle rather narrow, the basal cell dark red-brown below, nearly hyaline above; the central cell of the lower tier dark red or red-brown, lighter or hyaline at the base; the cells on either side symmetrical blackish brown opaque, extending upward so as to partly enclose the base of the second tier, the margins of the two tiers coincident: the second tier composed of from seven to nine cells, hyaline or becoming suffused below with reddish brown, bearing a well defined sharply pointed purplish slightly asymmetrical antheridium, on either side, which are subtended by from one to two typical rather short appendages: the upper tier very similar to the middle or slightly larger, nearly hyaline, the single perithecium rising to the right of the median appendage, the right half of the tier thus somewhat larger and higher than the left, three typical appendages usually present on either side. Perithecia $145 \times 26\ \mu$. Spores about $36 \times 4\ \mu$. Receptacle $120–140 \times 50\ \mu$. Total length to tip of perithecium $250–275\ \mu$.

On *Philonthus* sp. British Museum, No. 375. On abdomen.

Dichomyces exilis nov. sp.

Basal cell hyaline. Median cell of lower tier deeply suffused with brown but not opaque; marginal cells wholly opaque or translucent on the inner margins, extending upward so as to enclose the base of the second tier; second tier consisting typically of thirteen cells, colorless or partly suffused with brownish, the antheridia large brownish straight or slightly curved, the venter inflated, the cells external to them appendiculate, the outer three free above the marginal prolongation of the lower tier and forming a short blunt projection on either side: upper tier like the middle one mostly somewhat longer and narrower, consisting of from thirteen to fifteen cells, the sub-median ones nearly triangular and for the most part distally overlapped by the external cells next in order and the basal cells of the perithecia. Perithecia typically two, pale brownish amber, long and narrow, slightly if at all inflated, tapering gradually to the undifferentiated broad nearly truncate apex. Spores $35 \times 4\ \mu$.

Perithecia 130–140 × 22 μ. Receptacle 130–140 × 22 μ. Total length to tip of perithecium 250–275 μ.

On *Philonthus xanthomerus* Kraatz., British Museum (Biologia Coll.), No. 751, San Andres, Vera Cruz. On antennæ and anal appendages.

Dichomyces Angolensis nov. sp.

Basal cell hyaline. Lower tier opaque or the middle cell subhyaline, the marginal cells opaque, extending up on either side of the middle tier: middle tier relatively large, consisting of about thirteen to sixteen hyaline cells, the three to four external ones continuing the margin of the first tier directly and either subhyaline or blackened below, each bearing a normal appendage; the antheridia of medium size, brownish: upper tier smaller, shorter, and narrower than the middle one, consisting of from thirteen to fifteen hyaline cells: distally slightly concave, bearing a pair of perithecia, the appendages small, hyaline. Perithecium large and stout straight, faintly brownish, slightly inflated, tapering distally to the nearly symmetrical truncate apex. Perithecia 120–135 × 30 μ. Length to the tip of perithecium 250 μ. Greatest length of receptacle 140 × 75 μ.

On *Philonthus* sp. indet. British Museum, No. 379. Angola, Africa. On elytra.

Dichomyces insignis nov. sp.

Basal cell suffused with reddish brown or partly hyaline; the lower tier wholly opaque or translucent along the median line; the middle tier consisting of about thirteen to seventeen cells, exclusive of those which are indistinguishable in the slender fork-like prolongations which extend on either side higher than the middle of the upper tier, the margin broadly blackened, continuous with the opaque margin of the lower tier; the lower portion of the three to five median cells marked by a few large scattered transversely elongated brown patches which merge on either side into the opacity of the marginal cells; antheridia very large, the venter slightly inflated, the neck sharply pointed, conical, brown, often abruptly contrasting, three to five of the cells immediately external to them bearing normal brownish appendages: distal tier very large subtriangular, distally concave, consisting of from twenty-nine to thirty-nine narrow and elongated cells and bearing from four to eight perithecia with some irregularity; the appendages brownish, paired above the subtending cell, not as long as the perithecia. Perithecia relatively small,

purplish brown, tapering almost continuously from the broad base; the tip moderately well distinguished, the posterior lips prolonged to form long nearly straight and horizontal slightly inflated appendages which project from the tip on either side; the anterior lips forming the truncate apex, which consists of two distinct lateral projections with an intervening convex portion having a median apiculus. Perithecia about 85–30 μ, the appendages from tip to tip 35–39 μ. Antheridia 50×11 μ. Receptacle $300–340 \times 200–230$ μ. Total length to tip of perithecium 375–400 μ.

On an undetermined staphylinid collected by A. R. Wallace at Sarawak, Borneo, Hope Coll. No. 218.

Dichomyces biformis nov. sp.

Basal cell hyaline or nearly so, usually somewhat enlarged and often with a heel-like anterior projection; lower tier rather narrow, quite opaque, the marginal cells extending up to the subterminal marginal cell of the middle tier or to the cell next below it: the middle tier short and stout, the nine to eleven cells hyaline or faintly reddish brown above, usually becoming more or less suffused below and externally with brown; the median cells, where suffused, marked by darker transverse flecks on their anterior face, the marginal cells ending in a blunt distal often hyaline prominence on either side; antheridia short and stout subconical, subtended by a single brown inconspicuous appendage: the distal tier assuming in well developed individuals the form of a rather slender crescent, the number of cells very variable, the maximum about fifty, sometimes less than half this number, in which case the form is stouter, the marginal cells rarely extending above the tips of the perithecia which are four to eight in number and of two kinds which are not known to be associated on the same individual; in the one case they are stouter, purplish brown, the basal third or more often abruptly hyaline or nearly so, the much darker red brown tip tapering rather abruptly to the apex, which is hyaline nearly truncate, with a well defined median blunt projection; the posterior lip-cells prolonged much as in *D. insignis* to form a long horizontal nearly cylindrical or slightly tapering bluntly tipped hyaline appendage on either side; the second type more often longer and more slender than the first, pale reddish brown, the tip tapering, slightly truncate or blunt, often with a blunt median projection as in the first type, but without appendages. Perithecia $105–110 \times 20–35$ μ. Receptacle $200 \times 100–300 \times 270$ μ.

On *Philonthus* sp., Niagara Falls, New York, Mr. Charles Bullard: on

Philonthus umbratilis Grav., British Museum, No. 362, Leicester, England; Paris Museum No. 206 and British Museum, No. 407, Madeira; Paris Museum, No. 175, St. Pierre et Miquelon.

Dichomyces hybridus, nov. sp.

Basal cell small hyaline with a red brown suffusion near the base: lower tier narrow and elongate, opaque or sometimes with a median translucent line: middle tier rather narrow, not more than five of the median cells distinguishable, and more or less conspicuously marked on the anterior side by dark transverse flecks or striæ; distally hyaline or merely tinged with reddish brown above, becoming red-brown and finally opaque below; the margins opaque, continuous with those of the first tier and extending upward to form fork-like opaque projections, as in *D. furciferus*, which equal or exceed the upper tier in length; a single appendage arising posterior to the rather small purplish antheridium: upper tier relatively large, distally concave, composed of from fifteen to thirty-three nearly hyaline cells with reddish brown shades along the septa, the median cells sometimes flecked with reddish brown spots or transverse striæ towards the base, bearing two to six perithecia which may be of two types associated on the same individual or occurring on different individuals: the one type somewhat smaller, straighter and more erect, reddish brown, the lower half often abruptly paler or nearly hyaline, tapering rather abruptly to the tip, the lips of which are modified much as in *P. furciferus;* the other type larger, rather characteristically divergent, tapering rather abruptly to the truncate unmodified apex; appendages hyaline, sometimes as long as or even longer than the perithecia. Spores 35 × 4 μ. Perithecia 100–115 × 25–30 μ. Total length to tip of perithecium 250–300 μ. Receptacle 175–250 × 85–145 μ.

With both types of perithecia: on *Philonthus aeneipennis* Boh., Paris Museum, No. 203, Gulf of Oman, India; on *Philonthus* sp., British Museum, No. 366, Sylhet, Assam, India; on *Philonthus* sp., British Museum, No. 368, Hong Kong, China.

With only one form of perithecium (not appendiculate): on *Philonthus ventralis* Grav., British Museum, Ealing, England; Paris, No. 207, Funchal, Madeira; British Museum, No. 426, Europe; on *Philonthus* sp. British Museum, No. 495, Balthazar, Grenada, West Indies; British Museum, No. 369, China; on *P. proximus* Woll., British Museum, No. 403, Canaries; on *P. gemellus* Kr., British Museum, No. 367, Ceylon; on *Philonthus* sp., Niagara Falls, N. Y. (C. Bullard).

Dichomyces Madagascarensis nov. sp.

Basal cell deeply suffused with brown. Lower tier very long and slender, opaque except for a faint median translucent line: middle tier with three to five of the median cells distinguishable, red-brown; the rest indistinguishable in the opaque margins which extend upward to form long fork-like outgrowths on either side that may reach nearly to the tips of the perithecia; antheridia not large, brownish: upper tier consisting of about twenty-one to twenty-three cells, tinged with reddish brown, relatively large, deeply concave distally; the median cells like those of the middle tier, marked by fine faint transverse striæ, bearing normally two perithecia which are long and slender, often slightly curved and divergent, pale reddish brown, the tip narrow, the posterior lip-cells forming two small, slightly divergent projections (like those of *D. furciferus* but relatively smaller) curved at the tips, the anterior lips meeting in a point between them. Appendages hyaline, sometimes equalling the perithecia in length. Spores very slender and abundant, $35 \times 2\,\mu$. Perithecia $125–135 \times 25\,\mu$. Total length to tip of perithecium $320–350\,\mu$. Receptacle $225–240 \times 105\,\mu$.

On *Philonthus Sikorae* Fauv., Paris Museum, No. 179, Tananarivo, Madagascar. On abdomen.

Dichomyces vulgatus nov. sp.

Receptacle short and stout, the basal cell small squarish hyaline; the lower tier externally opaque, except the whole or the middle of the median cell or only its upper end, the opaque margin divergent extending above the base of the second tier, the blackened margin of which is continuous with that of the first tier; sometimes, like it, divergent, more often abruptly less divergent or even erect, extending upward to form on either side free fork-like, usually opaque, sometimes hyaline projections as in *D. furciferus* which may extend to a point somewhat above the base of the perithecia or may be almost obsolete; the three middle cells of the middle tier usually more or less conspicuously punctate below, with transversely elongated blackish brown spots: the antheridia normally placed, unusually long and large, pointed, with two or three short, inconspicuous normal appendages placed one behind, the rest external to it. The upper tier distally concave, consisting of from fifteen to twenty-one cells, producing normally four perithecia associated as usual with short stout typical appendages. Perithecia usually erect, straight, rather stout, pale reddish

amber brown, the lower half or third often abruptly lighter, tapering to a blunt tip which bears on either side a short, stout, often slightly recurved ear-like outgrowth as in *D. furciferus* formed by the prolongation of the anterior lip-cells, the posterior lips forming a usually angular, sometimes sharply pointed projection between them. Antheridia purplish, nearly straight or slightly curved, rather abruptly enlarged below the sharply pointed apex, the venter somewhat inflated. Perithecia 80–100 × 25 μ. Antheridia 35 × 7 μ. Total length to tip of perithecia 200–225 × 100 –115 μ. Appendages 35 μ.

On *Philonthus flavolimbatus* Erichs., Panama, British Museum, No. 750 (Biologia Coll.); *P. parvimanus* Sharp, Chontales, Nicaragua, British Museum, No. 746 (Biologia Coll.); *Philonthus* sp., Mt. Gay, Est Grenada, West Indies, British Museum, 489 (Smith Coll.); *P. sabalarius* Nord., British Museum, No. 406, Madeira; *P. longicornis* Steph., British Museum, No. 408, Island of St. Helena; *P. cruentatus* Gmel., British Museum, No. 358, Europe; *P. varians* Peck, British Museum, No. 359, Ealing, England; *P. dimidiatus* Er., British Museum, No. 761, Notting Hill, England. On abdomen. A form, apparently this species, also from Hong Kong, on *Philonthus* sp., British Museum, No. 396.

Dichomyces Cafianus nov. sp.

Tinged with dull amber brownish throughout, the perithecia darker. Basal cell nearly hyaline, the lower tier as in *D. vulgatus*, the opacity involving in general but half of the upper (external) cells, the septa of which are visible on the inner side, the median cell dark brown, its lower half or more opaque: the middle tier consisting of typically thirteen cells, the margins unmodified and ending in a short external rounded projection, which does not extend beyond the base of the upper tier; the rather inconspicuous antheridium normally placed, concolorous, a single short appendage close behind it: the upper tier consisting of from nineteen to twenty-three, usually twenty-one, cells, forming an inverted crescent, the short, stout, bladder-like appendages arranged as in *D. vulgatus*. Perithecia normally two in number, somewhat inflated externally, nearly straight, slightly asymmetrical, rather stout, tapering to the bluntly pointed undifferentiated tip. Spores 45 × 4.5 μ. Perithecia 120–140 × 35–40 μ. Receptacle 200–250 × 100–140 μ. Total length to tip of perithecium 310–350 μ. Appendages about 20 × 6 μ.

On *Cafius puncticeps* White, British Museum, No. 381. Colenso (S. Africa?).

Dichomyces dubius nov. sp.

Receptacle much as in *D. princeps* and similarly colored, smaller, shorter, and stouter, antheridia large purplish; the distal tier of cells producing typically two, rarely more, perithecia, which are pale brownish and dimorphous; usually rather slender, tapering slightly, the posterior lip-cells producing ear-like outgrowths recurved or bent forward as in *D. vulgatus:* more rarely larger and stouter, the blunt, often asymmetrical tip without appendages; the two forms sometimes, but not usually, associated on the same individual: external appendages normally large, long, colorless, reaching to the middle of the perithecium or even to its tip. Individuals asymmetrical, with a single antheridium and perithecia of the second type, are not infrequently met with on the legs of the host. Perithecia 70–90 × 20 μ, those without appendages 70–105 × 30–35 μ. Spores 35 × 4 μ. Receptacle about 120 × 75 μ. Total length to tip of perithecium average 190 μ.

On *Philonthus* sp., Niagara Falls, New York. On all parts of host. On hosts received from Mr. Charles Bullard. Possibly a variety of *D. princeps*, to which it is very closely allied. None of the abundant material of the latter from different parts of the world, however, show any tendency to produce an auricled type of perithecium.

Dichomyces Peruvianus nov. sp.

Receptacle with faint brownish shades especially along the septa, almost in the form of two superposed isosceles triangles, the lower very regular, including the basal cell and the first and second tiers, its distal margin horizontal, the upper truncate at the base and distally concave. The basal cell short, the lower tier consisting of from three to four cells, nearly equal in length; the middle tier of typically thirteen cells, the antheridia of medium size, the outer five cells distally appendiculate, one of the appendages situated behind the antheridium as usual; the distal series consisting of usually twenty-seven cells bearing typically four perithecia, the appendages placed as usual, colorless, somewhat shorter than the perithecia, which are mostly brownish externally and hyaline on the inner side, the brown or reddish fawn color sometimes predominating, asymmetrical, somewhat inflated, slightly bent inward near the tip which is small, pointed, and well distinguished. Perithecia about 120 × 30 μ. Receptacle 207–240 × 140–175 μ. Appendages 185 μ (longest). Total length to tip of perithecium 300–350 μ.

On *Brachyderus simplex* Sharp. In Dr. Sharp's Collection, Peru. On elytra and abdomen.

Peyritschiella Amazonica nov. sp.

Perithecium translucent brown, about as long as the receptacle, subclavate large, contracted below to form a neck-like base, somewhat inflated distally, the tip well though not abruptly distinguished, tapering to the nearly truncate apex formed by the slightly expanded tips of the lip-cells which are otherwise unmodified. Receptacle rather narrow, pale translucent brown, consisting of a single basal cell followed by three tiers of cells; the lower symmetrical or nearly so consisting of three long narrow nearly equal cells not appendiculate and not projecting laterally: the middle tier asymmetrical, consisting of about twelve cells, the series projecting distally on either side, all the cells except the three larger median and the external ones producing distally short typical appendages, the third cell on the right from the median cell bearing a prominent erect antheridium: the terminal tier very similar to the middle one, consisting of about the same number of cells which produce short typical appendages distally and (in the types) a single nearly median perithecium. Perithecia 200-210 × 36 μ. Receptacle 225 × 70 μ. Antheridium 45 μ long. Total length to tip of perithecium about 400 μ.

On an undetermined staphylinid. British Museum, No. 400. Nanta, Amazon River.

Peyritschiella protea nov. sp.

Perithecia translucent, brownish amber colored, rather stout and symmetrically inflated, the symmetrical tip tapering rather abruptly, the apex rather narrow truncate, the lip-edges unmodified. Receptacle nearly or quite hyaline, consisting of a single basal cell, above which the three typical tiers of cells are very variously developed : the lowest of these may rarely consist of a single cell, often of three which do not project laterally, or in well-developed specimens of as many as twelve or more cells, those external to the middle three forming on either side distal external angular usually asymmetrical projections, one or both of which may bear terminally one or even two perithecia and typical appendages : the middle series like the lower when the latter is well developed, subtriangular in form, consisting of sometimes as many as fifteen to eighteen cells, generally somewhat asymmetrical ; a single perithecium usually arising distally from the projecting portion on either side, together with numerous typical appendages: the distal tier similar to the middle one, mostly smaller, somewhat asymmetrical, bearing usually a single perithecium above the

median cell, though not produced from it, the remaining cells bearing typical appendages, often as long or longer than the perithecium, the small subtending cell being unusually well defined. Subject to great variation, and sometimes producing more than one antheridium. Perithecia 80–96 × 32 μ. Receptacle 270 × 80–100 to 120 × 45 μ. Total length to tip of perithecium 200–350 μ.

On *Bledius bicornis* Germ., British Museum, No. 392, Europe (Thuringia), No. 432, Europe; on *Oxytelus rugosus* Fabr., British Museum, 450, Hampstead, England; on *Acrognathus mandibularis* Gyll, British Museum, No. 434, Europe. On legs, elytra, and prothorax. In small specimens the two lower tiers may be but slightly developed, bearing neither appendages nor perithecia, the middle producing one antheridium, the number of cells and appendages on one side of the perithecium being as in all cases greater than on the other.

LIMNAIOMYCES nov. genus.

Receptacle consisting of two portions, a basal part below the perithecium and a distal part united to its posterior margin; the basal portion consisting of a single basal cell, surmounted by two tiers of cells (somewhat as in *Peyritschiella*), the anterior cell of the upper tier giving rise to a compound antheridium in structure similar to that of *Peyritschiella:* the distal (marginal) portion consisting of an inner and an outer elongated cell, the inner terminating in one of the bell-shaped appendiculate cells characteristic of *Chitonomyces,* separated from the simple appendage by a broad, constricted, blackened septum; the outer by successive subterminal external proliferations forming a series of cells from which a smaller secondary appendiculate cell is separated above, the whole corresponding in development to the external portions of the tiers of cells in *Dichomyces*, the proliferation taking place to the right and left successively, so that the appendages appear to arise in two rows.

A clearly defined genus apparently intermediate between *Peyritschiella* and *Chitonomyces.*

Limnaiomyces Tropisterni nov. sp.

Perithecium amber brown, straight, erect, with a slight nearly median inflation or tapering but very slightly to the undifferentiated tip; the upper half free. Receptacle pale straw colored, distally dull amber brownish, the foot minute, black; the basal cell short and small, the lower tier consisting of two cells which are nearly equal, several times

as long as broad: the second tier consisting of three cells, the posterior one longest, the median longer than the anterior, which terminates in the antheridium, which is subtended by four basal cells, two of them outer and lower and separated by oblique partitions, while a smaller upper one lies on either side: above the antheridium two vertically elongated cells form the clearly defined base of the perithecium; external to these cells and somewhat obliquely separated from them lies the broad base of the inner marginal cell of the distal portion of the receptacle, which lies next above the middle cell of the upper tier, its cavity nearly obliterated above as the spores mature, the primary appendiculate cell which terminates it rather elongate; the proliferation of the outer marginal cell beginning quite near its base, forming a series of about eight cells separated by oblique septa and terminated by small appendiculate cells; the appendages very small, vesicular, brownish below. Perithecia 127–175 × 35–37 μ. Receptacle, basal part, 75–110 μ, distal part 75–110 μ. Appendages 6 × 3 μ. Total length to tip of perithecium 240–375 μ, to tip of receptacle 190–265 μ.

On *Tropisternus* sp. indet., Paris Museum, No. 47. Mexico. On tip of abdomen.

Limnaiomyces Hydrocharis nov. sp.

Hyaline. Perithecium rather stout and short, somewhat inflated, its tip abruptly bent outward, the apex bluntly rounded or nearly truncate; the tip and the appendiculate cell usually symmetrically divergent. Basal portion of the receptacle relatively short and stout but otherwise similar in structure to that of *L. Tropisterni;* the two basal cells of the perithecium almost obliterated at maturity so that its base appears to rest immediately on the antheridium; the distal portion of the receptacle bordering the perithecium to its tip, the inner cell becoming almost wholly obliterated in the middle and terminating in a short bell-shaped appendiculate cell which is slightly divergent: the outer marginal cell usually proliferating three times; of the three cells thus formed the two inner, as a rule, produce well developed, long, simple, hyaline appendages; not, however, as well developed as the primary appendage, which may be twice as long as the perithecium. Spores 50 × 3 μ. Perithecia 60–80 × 17–20 μ. Receptacle, basal part, 50 × 20–26 μ, distal part 50–62 μ. Appendages, longest, primary 140 μ, secondary 70 μ. Total length to tip of perithecium 100–128 μ.

On *Hydrocharis obtusatus* Say, Cutts Island, Kittery Point, Maine. At tip of abdomen.

Chitonomyces Floridanus nov. sp.

Pale straw colored with a smoky, brownish tinge, the basal and subbasal cells relatively large, the former rather elongate, the latter broader than long, the distal cell erect, conical, appendiculate, its basal septum horizontal. Perithecium relatively large, distally somewhat inflated, the posterior margin to the apex nearly straight, the tip moderately well distinguished, the inner margin strongly convex between the tip and the secondary appendage; the lip-cells each forming a more or less distinct papilla. Spores relatively large about 35 × 3 μ. Perithecia 70 × 28 μ. Receptacle, distal part, 62 μ, the two basal cells with foot 52 μ. Total length to tip of perithecium 120–138 μ.

On *Cnemidotus 12-punctatus* Say, Eustis Florida, October. On legs and elytra.

Chitonomyces aethiopicus nov. sp.

Perithecium red-brown, darker on the inner side, with faint transverse striations, somewhat curved; the inner lip-cells producing at the left a blackish brown projection directed obliquely outward across the tip and resembling a canine tooth, the inner lip-cell on the left producing a much smaller, blackish, inconspicuous, tooth-like projection; one of the inner wall cells abnormally developed, bulging inward against and almost overtopping the subterminal appendiculate cell, the greater portion of the margin of this outgrowth nearly horizontal and extending from the apex of the perithecium to the insertion of the subterminal appendage which is sunk in an abrupt depression between it and the base of the terminal cell of the receptacle. Receptacle nearly hyaline, strongly curved throughout, consisting of a long basal and subbasal cell which appear to lie side by side for nearly their whole length, the lower marginal cell of the distal portion almost obliterated by the body of the perithecium, the subterminal cell large triangular, the terminal cell about as large, and separated from it by a nearly horizontal septum; wholly free, abruptly geniculate, the distal portion much narrower, erect and black (the tip broken), abruptly distinguished above an external bulge of the portion below it. Perithecia 128 × 40 μ, the tooth-like projection 18 μ. Receptacle to tip 275 μ, the basal and subbasal cells including the foot 140 × 35 μ. Total length to tip of perithecium 255 μ.

On *Orectochilus specularis* Aubé, Paris Museum, No. 100, Gold Coast, Africa. On elytra.

Amorphomyces obliqueseptata nov. sp.

Male individual unknown.

Female individual, straw colored tinged with amber brown, the receptacle consisting of a very small basal cell and a short, broad, subbasal cell bearing the very large perithecium and without appendages. The perithecium broadly inflated at the base becoming gradually narrow distally, the tip blunt asymmetrical; the apex somewhat oblique, the asci and spores filling the perithecium in great numbers, developed from a single ascogenic cell. The spores obliquely septate $40 \times 7\,\mu$. Perithecium $200 \times 55–60\,\mu$. Receptacle without foot $35 \times 27\,\mu$.

On the antennæ of an undetermined staphilinid, British Museum, No. 398, Ega, Amazon River.

Teratomyces vulgaris nov. sp.

Perithecia one to three in number, usually symmetrical and straight, becoming clear purplish brown, often considerably inflated below and conical above; the tip blunt or sometimes slightly pointed, the basal cells variously elongated sometimes nearly as long as the perithecium proper and often longer than the usually well developed stalk-cell. Receptacle symmetrical, its basal cell nearly hyaline, the cell above it tinged with reddish brown and somewhat larger, the third cell like the subbasal, squarish and somewhat larger. Appendages nearly hyaline or suffused, never deeply, with reddish brown, comparatively few in number, rather stout and long in general, the curved beak-like terminations of other species wholly wanting; all the appendages or their primary branches distinguished by a blackish brown basal septum, some, often many of them distinguished by being closely septate above, the cells thus formed producing a series of lateral outgrowths projecting obliquely upward and superposed (the antheridia?) Perithecia $140–200 \times 45–60\,\mu$, their basal cells $40–120\,\mu$, the stalk-cell $35–126 \times 25\,\mu$. Receptacle to base of appendages $70–100\,\mu$. Appendages (longest) $175\,\mu$. Total length to tip of perithecium $325–450\,\mu$.

On *Quedius fulgidus* Fabr., British Museum, No. 354, Kiel, Germany; on *Q. fuliginosus* Grav., British Museum, No. 355, Europe; on *Q. truncicolus* Fair. (= *ventralis* Arag.), British Museum, No. 435, Great Britain; on *Q. cruentus* Oliv., British Museum, No. 422, Europe; on *Quedius* sp. indet., British Museum, No. 356, Canada; on *Q. fulgidus* Fabr., Hope Coll., No. 216, Europe; on *Philonthus?* sp. indet., British Museum, No. 365, Hungary.

Teratomyces Philonthi nov. sp.

Perithecia commonly two, long and slender, a basal middle and distal portion distinguished, corresponding to the basal, middle and the distal wall- and lip-cells, the basal portion slightly inflated, purplish, the middle distinguished from it by a slight elevation at the septa; the middle nearly hyaline, rather abruptly narrowed, its margin slightly concave owing to a slight distal enlargement, which, in mature specimens, distinguishes it rather abruptly from the much shorter narrower subconical mostly symmetrically truncate colorless distal portion; the stalk-cell rather short, concealed by the appendages; the basal cells forming a squarish base. Receptacle relatively small, symmetrical or asymmetrical, the basal cell translucent brownish, the subbasal cell very small, flattish, wholly involved by the deep nearly opaque suffusion of the lower half or more of the upper cell, which is nearly hyaline above. Appendages short, slightly exceeding the base of the perithecium, rather rigid, slightly divergent, for the most part dark brown; forming a rather dense tuft, many ending in pointed cells, the slender terminations straight or bent and forming the beak-like cells characteristic of the genus. Spores $36 \times 4\,\mu$. Perithecia $140–175 \times 25–30\,\mu$, the stalk-cell about $35\,\mu$. Receptacle about $85 \times 35\,\mu$. Appendages (longest) about $70\,\mu$. Total length to tip of perithecium $250–300\,\mu$.

On *Philonthus* sp. indet., British Museum, No. 365, Hungary.

Corethromyces Brazilianus nov. sp.

Perithecium and receptacle much as in *C. Cryptobii*, but differing distinctly in the character of its appendage, the inner main branch of which consists of from four to six cells, the others very short, all nearly opaque, the branchlets long rigid divergent, curved abruptly outward at the tips. Total length to tip of perithecium $200–375\,\mu$. Spores $28 \times 3\,\mu$. Perithecia $90–175 \times 28–38\,\mu$. Appendages to tip of branchlets $140–200\,\mu$. Two specimens from Colombia, apparently identical, are much larger; total length $610\,\mu$; branches of appendages $540\,\mu$; perithecia $450\,\mu$.

On *Cryptobium Brazilianum* Lec., Paris Museum, No. 173, Brazil; on *C. fasciatum* Erichs, Paris Museum, No. 197, Caracas, Venezuela; on *C. Flohri* Sharp, British Museum (Biologia Coll.), No. 762, City of Mexico; also from same collection on *C. venustum* Sharp, No. 758, Oaxaca, Mexico; on *C. similipenne* Say, No. 761, Mexico. The larger type on *Cryptobium* sp. indet., British Museum, No. 385, Colombia. On all parts of host.

Corethromyces purpurascens nov. sp.

Perithecia dull purple, mostly slender straight or slightly curved, nearly isodiametric or the outer margin convex; the base slightly broader, the junction of the basal and subbasal and of the subbasal and subterminal wall cells indicated by a distinct protrusion in well developed individuals, in which the tip is thus moderately well distinguished although in most cases, especially in smaller specimens, the margin forms an unbroken line from base to apex, the perithecium being sometimes distinctly inflated basally; the stalk-cell as in *C. Cryptobii* hyaline above, becoming opaque brown below. Basal cell of the receptacle purplish or brownish translucent, the rest opaque indistinguishable from the almost wholly opaque main body of the appendage, the oblique inner margin of which is followed by a series of hyaline or purplish cells, three or more in number which give rise to the erect branches; the primary branches sometimes purplish near the base but producing an erect tuft of branches and branchlets which are quite hyaline, more or less flexuous and tapering. Perithecia 100–150 × 25 μ. Total length to tip of perithecium 175–275 μ. Longest branches of appendages about 140 μ.

On *Cryptobium capitatum*, Paris Museum, No. 172, Brazil; on *Cryptobium* sp. indet., British Museum, No. 494, Balthazar, Grenada, West Indies.

EUCORETHROMYCES nov. genus.

General form as in *Rhadinomyces*, the receptacle consisting of two superposed cells, the upper giving rise to the perithecium and appendage. Perithecium as in *Rhadinomyces*, stalked. Appendage consisting of several superposed cells the distal one bearing terminally a series of branches which produce free flask shaped antheridia laterally, borne on short lateral branchlets or sessile.

Eucorethromyces Apotomi nov. sp.

Hyaline becoming tinged, especially the perithecium, with pale amber brown. Receptacle short, the subbasal cell usually smaller, its axis coincident with that of the stalk-cell. Perithecium rather slender, inflated toward the base, the distal half slender tapering slightly to the blunt unmodified apex, the basal cells rather small, nearly equal, the stalk-cell stout and well developed. Appendage divergent almost at right angles to the axis of the receptacle, its basal cell usually more than twice as large as the subbasal cell, which bears distally and anteroposteriorly a single, or partly double, row of from four to six branches, some of them

often elongate, slender straight or curved, suffused with dark blackish brown, hyaline along the inner margin at least toward the base, obliquely septate, the septa dark; the antheridia stout, flask shaped, subtended by a dark septum, borne singly and laterally or several together on short branchlets near the base. Spores 26 × 2 μ. Perithecia 100–125 × 25–28 μ, 35–38 × 14–18 μ. Receptacle 40 × 18 μ. Appendage without branches 50 × 16 μ. Total length to tip of perithecium 190–207 μ. The Celebes material somewhat smaller.

On *Apotomus xanthotelus* Bates, British Museum, No. 578, Celebes; on *A. rufus* Rossi, British Museum, No. 577, Europe. On elytra.

Rhizomyces crispatus nov. sp.

Perithecia brownish, rather stout: when viewed sidewise, the inner margin strongly convex, the outer nearly straight with a general median elevation or concave owing to a general outward curvature, tapering to the undifferentiated tip, the apex broad truncate, usually symmetrically bisulcate: viewed at right angles to this position straight symmetrical, abruptly enlarged below the narrow symmetrical abruptly distinguished tip: the basal cells well defined nearly isodiametric, the stalk-cell large, as long or longer than the perithecium. Receptacle two-celled, the foot typically modified and blackened without rhizoids, distally geniculate through a protrusion of the distal cell below the insertion of the stalk-cell and opposite that of the appendage. Appendage erect, sometimes exceeding the tip of the perithecium, consisting of a single series of superposed cells, the three or four lower suffused with smoky brown, the rest subhyaline, each cell except the basal one giving rise directly and externally to a branch, the insertion in successive cells being somewhat to the right and left of the median line so as to form two vertical rows, the basal cells of alternate branches being superposed; each branch consisting of a basal cell externally blackened, which gives rise above to a one-celled short branchlet, bearing usually a pair of long, slender antheridia, the remainder of the branch curved upward blackish brown except its upper margin, and giving rise from its lower (external) side to a series of close-set simple branchlets, black, recurved, more abruptly at the tips which are slightly enlarged and nearly hyaline, the whole suggesting the margin of a curled black feather. Spores 20 × 2.8 μ. Perithecia 65–75 × 27–30 μ, the stalk-cell 50–85 μ. Receptacle 30 μ. Appendages 140–175 μ.

On *Diopsis* sp., British Museum, No. 739, Natal, Africa.

Rhachomyces Philonthinus nov. sp.

Perithecia borne on a short broad hardly visible stalk-cell, reddish brown, inflated toward the base, conical above, straight and nearly symmetrical, the tip blunt, undifferentiated symmetrical. Main axis of the receptacle distinct, consisting of about twenty cells, including about eight to ten cells which form its erect free termination beside the base of the perithecium; the three lower cells mostly suffused with red brown, those above hyaline or partly suffused, increasing in size to about the eleventh cell, above which they become successively smaller to the tip of the free portion; the septa for the most part marked by rather prominent constrictions. Appendages numerous but not obscuring the main axis of the receptacle, slightly divergent, mostly tapering distally and slightly bent below the straight hyaline tips; those arising about the base of the perithecium longer and stouter, brown and mostly blunt tipped, about six in number and extending about to the middle of the perithecium. Spores about 40–45 × 4 μ. Perithecia 140–200 × 40–60 μ. Receptacle 220–340 μ. Total length to tip of perithecium 350–500 μ. Longest appendages about 100 μ.

On *Philonthus longicornis* Steph., British Museum, No. 408, Island of St. Helena; on *Philonthus* sp. indet., Hope Coll., No. 225, British Isles. On abdomen and elytra.

Rhachomyces velatus nov. sp.

Perithecium short stout straight symmetrical, evenly inflated pale brownish, translucent; the tip abruptly dark brown opaque or nearly so, tapering symmetrically to the blunt rounded apex. Receptacle varying in length, consisting of perhaps eighteen to twenty cells, the basal cell and sometimes two or three of those above it hyaline or nearly so, the rest indistinguishable, being concealed by the densely crowded appressed appendages, which are rather short and slender, deep brown or opaque except along the inner margin and at the tip; those around the base of the perithecium also densely crowded, subequal blunt-tipped, wholly suffused, completely enveloping it and wholly concealing it till it is fully developed when the tip alone projects beyond them. Spores about 35–40 × 3–4 μ. Perithecia 175 × 75 μ or smaller. Total length to tip of perithecium 400–550 μ. The longer appendages about 120 μ.

On *Colpodes agilis* Chaud., British Museum (Biologia Coll.), No. 696, Jalapa, Mexico; on *C. atratus* Chaud., British Museum (Biologia Coll.),

No. 698, Irazu, Costa Rica; on *Gynandropus Mexicanus* Putz., British Museum (Biologia Coll.), No. 682, Cordova, Mexico. Usually on legs.

Rhachomyces Thalpii nov. sp.

Perithecium hyaline or straw colored, becoming faintly tinged with brown, slender, inflated near the base; the distal half or less mostly curved away from the appendages, tapering gradually to the blunt undifferentiated apex. Receptacle normally consisting of eleven cells superposed to form the main axis, hyaline, their septa horizontal or but slightly oblique, the basal cell subtriangular, tinged with reddish brown; the cells of the secondary series hyaline and proportionately rather large. Appendages rather dense, almost opaque except the nearly or quite hyaline tip and inner margin; rather short, about four to six of those about the base of the perithecium much larger, longer, and stouter, reaching somewhat higher than the middle of the perithecium, their tips at first clavate becoming obliquely truncate or fan shaped through the degeneration of the hyaline portion, the curved tips of the antheridia projecting rather conspicuously. Perithecia $115 \times 30\,\mu$. Total length of receptacle $140\,\mu$. Longer appendages $90\,\mu$.

On *Thalpius rufulus* Lec., Amer. Mus. of Nat. History. Texas.

Rhachomyces Zuphii nov. sp.

Perithecium relatively small, straw colored, somewhat inflated at the base, the tip rather abruptly distinguished and slightly inflated. Axis of the receptacle slender, consisting normally of about sixteen cells which are nearly hyaline, or with brown shades below the septa. Appendages nearly opaque, straight stout appressed, not elongate, more or less swollen distally along the inner margin of the subhyaline tip; eight to ten about the base of the perithecium longer and stouter. Perithecia $110–140 \times 25\,\mu$. Longer appendages about $110–140\,\mu$. Total length to tip of perithecium $350–400\,\mu$.

On *Zuphium Mexicanum* Chaud., British Museum (Biologia Coll.), No. 713. Cordova, Mexico.

Rhachomyces Canariensis nov. sp.

Perithecium pale straw colored, nearly straight, a median and subterminal well-defined broadly-rounded ridge marking the transverse septa between the three lower tiers of wall-cells; the tip tapering rather abruptly, hyaline, the apex rounded. Receptacle rather slender, the

basal and subbasal cells relatively large, hyaline, the rest pale straw colored, the main axis consisting of fifteen or sixteen cells, the upper five or six forming a free erect termination. The appendages not numerous, appressed, brown; those about the base of the perithecium larger, distally blunt and hyaline, about two thirds as long as the perithecium. Perithecia 90–130 × 27–30 μ. Receptacle 175–225 μ. Appendages, longest, about 100 μ. Total length to tip of perithecium 250–325 μ.

On *Trechus flavomarginatus* Woll., British Museum., No. 419. Teneriffe. On elytra.

Rhachomyces tenuis nov. sp.

Perithecium relatively small, the lower half or more hidden by the appendages, hardly inflated, faintly tinged with brown, tapering very slightly to the tip, which is suffused with dark brown, broad, hardly differentiated and slightly asymmetrical. Receptacle very long and slender, the cells of the main axis thirty to forty in number, dark reddish brown or nearly opaque, subhyaline below the somewhat oblique septa, except the lower members of the series, which are as a rule wholly opaque; the cells increasing slightly in size from the base upward. Appendages straight, narrower distally, rather short and appressed, not very numerous; those about the base of the perithecium, about twelve in number, somewhat larger and longer than the rest, surrounding and concealing it more or less completely; some of the lower appendages also longer and curved conspicuously outward, as are the antheridia. Perithecia about 110 × 30 μ. Longer appendages about 140–160 μ. Greatest width of receptacle about 20 μ. Total length to tip of perithecium 800–1000 μ.

On the legs of a small carabid beetle, Paris Museum, No. 113. Java.

Rhachomyces Cryptobianus nov. sp.

Perithecium hyaline or pale straw colored, very long and slender, nearly isodiametric throughout, almost straight, the tip apparently blunt and not well differentiated. The main axis of the receptacle consists of about sixteen cells; the basal cell and those immediately above it slender black and opaque; the rest becoming larger upward, hyaline suffused or mottled with reddish brown. Appendages numerous slightly divergent, becoming longer from the base upward, nearly opaque except along the inner margin and at the tip which is generally bent abruptly

outward, a group of about six below the base of the perithecium much longer than the rest and curved outward in a tuft, those arising about the base of the perithecium very elongate, erect, with straight blunt tips, reaching nearly to the apex of the perithecium.

Perithecia 490–450 × (about) 35 μ. Receptacle 275–430 μ. Total length to tip of perithecium 650–800 μ. Longest appendages 300–430 μ.

On *Cryptobium capitatum*, Paris Museum, No. 172. Brazil.

Rhachomyces Cayennensis nov. sp.

Perithecium rather small, yellowish, the anterior margin nearly straight, the posterior convex; the tip clearly and abruptly differentiated, concolorous, asymmetrical, somewhat bent. Main axis of the receptacle rather strongly curved, consisting of about twelve cells; the basal ones slender, deeply suffused, those immediately above opaque slender, the rest rather large with central brown suffusions; the distal cells paler. Appendages rather coarse, crowded, black brown, opaque or nearly so, the tips mostly bent outward, appressed below, somewhat divergent distally; six or more about the base of the perithecium slightly longer than the rest, nearly equalling, sometimes slightly exceeding the perithecium in length. Perithecium 120–140 × 25–30 μ. Total length to tip of perithecium about 350 μ (average). Longest appendages 140 μ.

On *Cryptobium* sp. indet., British Museum No. 387. Cayenne. On the inferior surface of abdomen.

Rhachomyces stipitatus nov. sp.

Perithecium pale straw colored becoming tinged with brownish, much darker toward the tip; broadly subfusiform, usually symmetrical, tapering from about the middle to the small blunt usually symmetrical, hardly differentiated, often hyaline tip; borne free on a stalk-cell which is concolorous, sometimes as long as the receptacle, in other cases but slightly developed. Receptacle straw colored, or faintly brownish; the main axis consisting of about fifteen to seventeen cells, the septa rather oblique, its distal portion, consisting of about two to four cells, erect and free: the cells of the secondary axis relatively large, concolorous, that opposite the subbasal cell of the main axis bearing a long opaque blackish brown appendage curved toward the receptacle and often equalling it in length, other similar appendages arising at intervals above it but not from all the lower cells, becoming more numerous throughout the distal half and in some instances extending to or beyond the tip of the perithecium even

in the long stalked forms, associated throughout with shorter appendages and antheridia. Some of the individuals on *A. Lespezi* small, the main axis of the receptacle consisting of only seven cells, the perithecia nearly sessile and small in proportion. Spores 50–60 × 4 μ. Perithecia 140–150 × 45–69 μ (100 × 30 μ in small specimens), the stalk including basal cells longest 220 × 47 μ. Total length to tip of perithecium about 550 μ (200–680 μ). Receptacle 325 μ (110–350 μ). Appendages longest 400 μ.

On *Anophthalmus Rhadamanthus* Lind., Hope Coll. No. 306, Greece; on *A. Lespezi* Fair., Paris Museum; No. 185, Grotte des Capucini, Seine et Garonne, France.

Compsomyces Lestevi nov. sp.

Receptacle consisting of a small basal and subbasal cell, the latter giving rise to rarely more than two branches; one of which consists of a basal cell, from the upper side of which the stalk-cell of the perithecium arises; while externally it gives rise to a characteristic sterile branch, simple, usually slightly upcurved, rather closely and somewhat obliquely septate, commonly consisting of about nine superposed cells tapering rather abruptly at the tip. Perithecium borne on a well developed erect stalk-cell, nearly symmetrical, tapering from about the middle to the broad truncate undifferentiated tip; the basal cells small, but slightly distinguished from the inflated base of the ascigerous portion, the spores few and relatively large. The other branch arising from the subbasal cell of the receptacle, an antheridial branch, divergent, consisting typically of four superposed cells above which it becomes furcate, dividing into two branches which are large stout tapering, distally curved; the third cell of the appendage producing a single short flask-shaped antheridium distally on its inner side and sometimes giving rise to a branch similar to those above. Spores 42 × 4 μ. Perithecia 75–85 × 30–35 μ, the stalk 75 × 22 μ. Antheridial appendage including branches 275 μ, the basal part about 60 × 20 μ.

On *Lesteva sicula* Erich, British Museum, Nos. 452 and 453, Paisley and Red Hill, England. On abdomen and elytra.

CLEMATOMYCES nov. genus.

Receptacle consisting of a basal and a subbasal cell from which arises distally a main axis bearing a terminal perithecium and formed by a double row of cells; the cells of the external row producing sterile appendages,

those of the inner producing either secondary axes similar in structure to the primary one, or antheridial branches; the secondary axes producing antheridial or sterile branches on both sides, and like the primary ones bearing a single terminal perithecium. The antheridia simple, borne as in Compsomyces, usually several from the distal ends of successive cells.

Clematomyces Pinophili nov. sp.

Nearly hyaline or yellowish, the basal and subbasal cells small, the cells of the main axis in six to twelve pairs more or less alternate on either side, each cell of the outer series giving rise to a three or four celled usually simple generally appressed sterile appendage, the terminal cell of which is often smoky brown, its basal cell almost wholly united to the cell of the axis next above; the secondary axes one to three in number, usually with a single basal cell, the external branches more often simple and sterile, the inner fertile; the antheridial appendages of both primary and secondary axes more often simple, sometimes sparingly branched, those near the perithecia bearing the greatest number of antheridia which may arise singly or opposite in pairs, or in whorls of three or four from the distal (one to four) cells of the appendage. Perithecium solitary, sessile at the tips of the primary and secondary axes, often straight and symmetrical tapering to the truncate unmodified apex, pale becoming amber brown. Spores about $38 \times 3\,\mu$. Perithecia 100–150 $\times$ 25–40 μ. Sterile appendages, longer, $100 \times 7\,\mu$. Greatest length to tip of perithecium (main axis) 300–400 $\times$ 35 μ.

On *Pinophilus* sp. indet., British Museum, No. 390, Burmah, India. On inferior surface.

Sphaleromyces obtusus nov. sp.

Perithecia relatively large, clear dark brown becoming almost opaque; the inner margin nearly straight, the outer strongly convex; tapering very slightly basally and distally; the tip paler brown, abruptly distinguished, and when viewed sidewise flaring, with straight divergent lateral margins, the distal margin as broad as the portion of the perithecium below the tip and slightly concave, the outer lips more prominent and much broader than the inner: when viewed at right angles to this position the tip appears in general bluntly rounded not expanded, the more or less papillate tips of the lip-cells situated in asymmetrical pairs, which are visible above and below a broad bluntly rounded median portion between them: the basal cells colored like the perithecium, distinct,

hardly broader than the stalk-cell which is hyaline contrasting thick-walled and about twice as long as broad. Receptacle small, suffused with brown, two celled; the septa somewhat oblique, the upper cell contrasting abruptly with the colorless stalk-cell, and giving rise laterally to the slightly divergent appendage, which consists of from five to six nearly opaque brown cells, separated by oblique septa; each producing distally on the inner side a short hyaline branch, sometimes once branched. Spores about $40 \times 3.5\,\mu$. Perithecia 140–150 $\times$ 40-45 μ, the stalk-cell $35 \times 20\,\mu$. Receptacle not including foot 27–35 $\times$ 10 μ. Appendage, mostly broken 70–100 μ. Total length to tip of perithecium 230–245 μ.

On *Lathrobium Illyricum* Dej., British Museum, No. 384. Algeria(?). On superior surface of abdomen.

Sphaleromyces propinquus nov. sp.

Like *S. obtusus* in size, form, and color, except that the tip of the perithecium is symmetrical or nearly so, the lips forming a broadly rounded blunt terminal prominence with sometimes a slight median elevation, while at the base the tip is characteristically broadened through the presence of distinct lateral elevations on either side: the stalk-cell rather abruptly swollen below the basal cells of the perithecium.

On *Lathrobium*, sp. indet., British Museum, No. 383. Europe. On superior surface of abdomen.

This species is doubtfully separated from *S. obtusus* on account of the very different conformation of the tip of the perithecium, which, as the material in either case occurred in the same position on the host, can hardly be due to position of growth.

Sphaleromyces atropurpureus nov. sp.

Perithecium large, purplish, more or less distinctly curved away from the appendages, tapering below, often broader distally above the middle, tapering thence slightly to the tip, which is usually not distinctly differentiated; the apex small truncate or slightly papillate; the basal cells large, as long as or longer than the stalk-cell, dull amber brown. Basal cell of receptacle large, not greatly elongated, tapering below, the nearly hyaline distal portion obliquely distinguished from the deeply suffused, partly opaque portion of the cell below; the subbasal cell subtriangular. Appendage consisting of about five cells decreasing in size from below upward, the septa nearly horizontal; those above the basal cell giving

rise to a branch on the inner side, which in the subbasal cell and the cell above it consist of a very large broad basal cell, from which arise from two to four subhyaline branches which may be once branched, the branches crossing the stalk and basal cells of the perithecium obliquely, usually on the left side, so that when the perithecium lies at the left, the appendages lie above them. Spores 35 × 3.5 μ. Perithecia 175–200 × 30–35 μ, the stalk and basal cells together 50–70 × 17–20 μ. Receptacle 85–100 × 40 μ. Total length to tip of perithecium 270–350 μ. Appendage without branches 50–75 μ.

On *Quedius graciliventris* Sharp, British Museum, No. 740 (Biologia Coll.), Volcan de Chiriqui, Panama; on *Q. basiventris* Sharp, No. 741, from same locality. On abdomen.

Sphaleromyces Brachyderi nov. sp.

Perithecium evenly suffused with brown, paler distally, somewhat inflated at the base, tapering slightly toward the tip; an external deep brown almost opaque appendage projects subterminally, exceeding the tip of the perithecium, broad with a nearly median indentation of the inner side, the outer margin slightly, the upper strongly curved outward, terminating in a short blunt point or slightly inflated portion rather abruptly distinguished on its inner side; the tip asymmetrical, one of the outer lip-cells extending above and free from the others, forming a hyaline bluntly pointed termination at the base of which the tips of the other lip-cells form irregular prominences; basal cells concolorous, stalk-cell short and similar to the basal cells. Basal cell of the receptacle very large, long, attenuated below and deeply blackened, as in Camptomyces, the distal cell subtriangular concolorous with the stalk-cell. Appendage consisting of four or five rather flattish brown cells, decreasing in size from below upward, their septa directed obliquely outward and downward, each producing a branch from its upper inner angle, which is simple or one or more times branched, the branchlets subhyaline. Spores about 30 × 3 μ. Perithecia 120–140 × 28–35 μ, its appendage 35 × 12 μ. Receptacle 85–100 × 30–35 μ. Primary appendage about 35 μ, with branchlets about 120 μ. Total length to tip of perithecium 225–260 μ.

On *Brachyderus antennatus* Sharp, in Dr. Sharp's Coll. Peru.

MISGOMYCES nov. genus.

Receptacle consisting of numerous cells superposed singly or in tiers of two to three cells each, terminating in a more or less irregularly cellular base bearing appendages singly or in groups. The solitary perithecium arising beside the appendages, the two situated in relation to one another as in Laboulbenia.

The antheridia could not be recognized in the material examined, the appendages being more or less broken in all cases, but are doubtless simple, the genus being probably related to Laboulbenia, while at the same time it suggests some forms of Ceratomyces.

Misgomyces Dyschirii nov. sp.

Rather rich amber brown, the receptacle consisting of from eight to twenty-three superposed cells, the upper ones rarely divided longitudinally, the distal cell lying between several, usually three, smaller cells which become separated from it on either side, and which, together with its base, are united to the base of the perithecium; while above it, and separated from it by a thin dark insertion, a cellular base gives rise to the group of appendages, the irregular basal cells of which alone remain in the material examined. Perithecium nearly oval or very slightly pointed, the tip and lips undifferentiated. Spores, seen only in perithecium, with base apparently abruptly recurved or bent, about 60 × 3.8 μ. Perithecia 70–85 × 35–40 μ. Receptacle 135–400 μ. Total length to tip of perithecium 200–435 μ.

On *Dyschirius globosus* Herbst., Hope Coll., No. 349, England; on *D. salinus* Schaum., British Museum, No. 582, Europe.

Misgomyces Stomonaxi nov. sp.

Hyaline or pale straw colored. Receptacle consisting of a basal and one or two more single superposed cells, the cells above these becoming rather irregularly divided longitudinally to form a double row of variable length, above which a second longitudinal division appears, the receptacle in this region being made up of three-celled tiers as far as the base of the perithecium, above which its distal part consists of several superposed pairs of cells, or of two rows of cells more irregularly distributed, the insertion of the appendages rather indefinite, the cells composing it producing irregular hyaline or brownish branches distally. Perithecium externally nearly straight, the inner margin convex, the tip rather abruptly

differentiated, straight or curved outward. Perithecia 90–100 × 25-30 μ. Receptacle 300–335 μ. Total length to tip of perithecium 365–400 × 40–45 μ.

On *Stomonaxus striaticollis* Dej., British Museum No. 593, China. On elytra.

Ceratomyces Floridanus nov. sp.

Purplish brown. Perithecium much as in *C. confusus*, the outer margin nearly straight, the inner somewhat convex, the two inner rows of wall cells, about twenty-four in number, rich red brown with a blackish tinge distally; the outer wall cells, about nineteen in number below the perithecial appendage abruptly and evenly paler, yellowish straw color or faintly brownish; the twentieth cell (about) forming the base of the perithecial appendage which is black, quite opaque, curved outward and upward and geniculate near its base the inner margin of which is abruptly distinguished (not continuous with the adjacent margin of the tip as in *C. confusus*); the tip distally hyaline, the apex forming a prominent symmetrical well defined rounded hyaline papilla. Receptacle consisting of three superposed cells almost wholly black and opaque except along their anterior margins and the distal margin of the upper cell, which are pale straw yellow or amber colored, the series surmounted by two small flattened cells from which arise the perithecium and appendage respectively. Appendage long tapering, consisting of seven or eight superposed cells, clear reddish brown with a blackish tinge, the inner margin as well as the distal portion yellowish or amber colored. Perithecia 300–325 × 60 μ. The appendage 150 μ. Receptacle 150–160 × 75 μ. Appendage about 175–200 μ.

On *Tropisternus glaber* Hb. Eustis, Florida, October. On margin of left elytron.

Ceratomyces cladophorus nov. sp.

Perithecium very large with a slightly sigmoid curvature, the lower half conspicuously inflated above the rather narrow base, the outer margin of the inflated portion strongly convex, the inner slightly concave; the distal half or third more nearly isodiametric, bulging subterminally on the inner side, the margin curving thence abruptly outward to the short broad beak-like tip; the apex sometimes apiculate; about the fortieth cell of the outer row of wall-cells forming the base of a subterminal appendage which is curved upward, geniculate at its base, rather long slender and tapering, amber brown becoming blackish below; the peri-

thecium at first pale yellowish, the inflated portion becoming rich amber brown, the distal portion much paler except in the region of the more deeply suffused subterminal elevation on the inner side. The narrowed base nearly hyaline, not differentiated from the receptacle. Receptacle consisting of three superposed cells, short, narrow below, abruptly very broad above; the foot relatively small, the basal cell small, at first hyaline, later becoming tinged with smoky brown; the two distal cells relatively very small and broadly blackened except along the nearly hyaline anterior margin, the opaque area extending obliquely so as to involve the geniculate base of the appendage. Appendage relatively very large and stout, tapering in very young individuals to a slender apex and consisting of from fifteen to twenty superposed cells, many of which may be once longitudinally divided, a subtriangular appendiculate cell being separated from the inner side, or also from the outer distally; the branches numerous with very long and slender branchlets which may be several times branched. Spores 95 × 4 μ. Perithecia 475–550 × 90–110 (inflated portion) × 70 μ (distal portion). Receptacle including foot 85 μ. Total length to tip of perithecium (longest) 635 μ. Appendage 275–475 × 45 μ, its longest branches 550 × 3 μ.

On *Tropisternus nimbatus* Say. Eustis, Florida. On the inferior surface of the thorax on the left side.

Ceratomyces denticulatus nov. sp.

Similar to *C. rostratus*. Amber brown, the ascigerous portion of the perithecium slightly inflated and rather abruptly distinguished from the elongate neck, which at maturity is straight or slightly sinuous; the cell rows containing about fifty-five cells, the neck more slender toward the base, distally somewhat broader; successive cells in two adjacent rows in this broader portion projecting to form well marked rather slender tooth-like blunt outgrowths, directed obliquely upward and separated by a basal septum, one series usually consisting of five cells, sometimes six, the cells immediately below often bulging prominently or forming shorter tooth-like outgrowths; the second series consisting of usually not more than three well defined similar tooth-like outgrowths: above these two series the upper fifth (about) of the neck is bent abruptly backward, lying nearly parallel to the portion below it; the tip broad snout-like, the lip-cells forming a small papillate prominence above and external to a broad rather distinctly differentiated cell, which terminates one of the inner rows, and is almost as large as the lip-cells taken together. Re-

ceptacle rather slender, tapering to the base, consisting of (invariably?) ten superposed cells, exclusive of the foot-cell, which is not always wholly blackened. Appendage as in *C. rostratus*, the numerous branches and branchlets rather slender, not very long, forming a rather compact tuft more or less appressed around the base of the perithecium. Perithecium, ascigerous portion about 85 × 35–40 μ, neck to recurved portion 475–500 × 20–25 μ, recurved portion about 125 μ, tooth-like projections 15–35 × 6–7 μ. Receptacle (ten superposed cells) 130–150 μ. Appendages (longest branches) 175 × 3 μ.

On a small hydrophilid beetle, Paris, Mus., No. 11, Îles Mariannes, on under surface, and legs.

Ceratomyces elephantinus nov. sp.

Closely resembling *C. denticulatus*, rather faintly tinged with pale amber brown, the neck proportionately somewhat broader; the upper three sevenths to four ninths abruptly recurved, certain adjacent cells of two opposite rows just below this curvature producing broad rather short blunt tooth-like outgrowths, one to two and three to four in each respectively; the tip broad slightly and irregularly sulcate. Receptacle consisting of from seventeen to twenty-two squarish or flattened cells, sometimes hardly broader distally. Appendage producing numerous long slender flexuous branches repeatedly branched. Perithecia, ascigerous part about 140 × 65 μ, neck to recurved part 475–525 μ, recurved part 390–400 μ. Spores 70 × 3.5 μ. Receptacle 375–550 μ. Longest branches of appendage 600 μ.

On *Hydrobius* sp. ?. Eustis, Florida, October. On legs.

Ceratomyces rhynchophorus nov. sp.

Hyaline. Receptacle long slender, but slightly narrower below, consisting of about forty (thirty-five to fifty) superposed cells, wider than long; those in the lower half more flattened, the foot small. Perithecium lateral, nearly erect, slightly divergent; a short but definite stalk-cell; the cells at the base greatly elongated, extending some distance up around the ascus mass and forming together with the large elongated supporting cell a broad sterile base to the perithecium which is not differentiated from its main body; the cell rows consisting of but five cells, including the very small lip-cells, and the cells of the sterile base; the three upper tiers of cells forming an abruptly differentiated, thick walled, long, tapering beak-like termination, curved outward or inward, often

at right angles; below which the distal end of the outer wall-cell forms a slight rounded prominence, the very small lip-cells forming a slight enlargement. Appendage similar to and continuing the axis of the receptacle directly, or diverging very slightly; the cells giving rise to branches on opposite sides which are subtended by small cells obliquely separated at the distal angles, those from the lower cells short (antheridial ?), those from the upper long and several times branched; the main appendage usually broken, but in young individuals consisting of from twenty to twenty-five superposed cells. Spores 48 × 3 μ. Perithecia, ascigerous portion 175 × 45–50 μ, beak-like termination 140–160 μ, sterile basal portion about 100 μ. Receptacle 270–430 × 30–35 μ. Appendage (young individuals) 350 μ, the branchlets 200 × 6 μ.

On *Phænonotum estriatum* Say. Eustis, Florida, October. On legs and inferior surface. A form growing on the lower surface of the apex of the elytron has enormously developed perithecia with a maximum length of one millimetre.

Ceratomyces reflexus nov. sp.

Closely allied to *C. rhynchophorus*. Hyaline with a few purplish or reddish suffusions on the receptacle, which is composed of from about twenty-five to fifty superposed cells; the foot hyaline, or slightly yellowish, much enlarged, bladder-like or spherical; the distal portion distinctly broader, its axis coincident with that of the erect appendage which forms a direct continuation of it. Perithecium small with few asci, abruptly recurved at the base, its apex thus sometimes touching the inflated foot; nearly straight, tapering almost symmetrically to the blunt slender tip; the ascigerous cells situated at the base just above the small angular stalk-cell. Appendage usually flat and broader than the receptacle towards its base, the superposed flat cells of which it is composed producing appendages on either side much as in *C. rhynchophorus*. Spores 70 × 4 μ. Perithecia 140 × 20 μ. Receptacle 140–280 μ. Appendage 200–400 μ. Foot about 30 × 30–38 μ.

On *Phænonotum estriatum* Say. Eustis, Florida, October. With *C. rhynchophorus*.

Ceratomyces acuminatus nov. sp.

Hyaline. Receptacle consisting of three superposed cells, the basal cell partly suffused and continuous with the blackened foot. Perithecium rather stout, the outer margin nearly straight, the inner strongly convex; the seventh wall-cell of the inner row greatly enlarged, its outer wall

very thick, forming an erect tapering bluntly pointed terminal appendage, at the base of which the papillate apex of the lip-cells projects on the right side; the fifth cell of the external row of wall-cells growing out to form a subterminal slender appendage, eight-celled in the type, distally attenuated, its terminal cell bearing one or two slender branches. Appendages consisting of from four to five superposed cells, the distal ones appendiculate (the branches mostly broken). Perithecium 185 × 40 μ. The appendage without branches 82 μ, the branches 150 μ; the rostrate terminal cell 50 × 17 μ (at base). Receptacle 85 × 48 μ. Spores about 70 × 3.5 μ. Appendage, broken, without branches 70 μ.

On *Berosus* sp. indet. Eustis, Florida, October. On the inferior surface of abdomen and thorax.

Ceratomyces Californicus nov. sp.

Allied to *C. camptosporus*. Amber brown. Receptacle relatively slender, consisting of three small superposed cells surmounted by two similar cells which form the base of the appendage and perithecium; the foot small, normal. Perithecium short and stout, from two to three times as broad distally as at the base; about twenty cells in each of the inner rows of wall cells, the inner margin convex, distally abruptly bent inward to the short beak-like apex; the conformation of the tip, the inner margin of which is thus horizontal or even oblique, resembling that of *C. ornithocephalus;* about the eighteenth cell of one of the outer rows forming the base of the usually straight rather remotely septate perithecial appendage which commonly diverges at an angle of forty-five degrees or even at right angles. Appendage small and slender (the extremities broken in the types) becoming lateral in position. Perithecia 185–200 × (base) 30–40 (distal portion) 70–85 μ. Receptacle 50–70 × 25 μ. Total length to tip of perithecium 250–300 μ.

On *Tropisternus dorsalis* Brullé. California. On the left anterior inferior angle of the prothorax.

Ceratomyces ornithocephalus nov. sp.

Allied to *C. furcatus*. Hyaline or becoming more or less suffused with amber brownish. Perithecium relatively rather small, the external margin somewhat concave, the inner convex, the four distal cells of the eight external wall-cells rather abruptly enlarged, their external walls much thickened and forming an irregularly rounded crest-like prominence, the distal half of the margin of which becomes abruptly

almost horizontal, terminating near the base of the beak-like pointed apex, which projects somewhat obliquely from the right side: the external row of wall cells producing above the fourth cell a large appendage, geniculate at its base, tapering distally where it curves outward, consisting of from ten to twenty cells, the terminal cell rarely bearing one or more slender branches. Receptacle consisting of three superposed cells, the basal one usually opaque, except distally, and continuous with the foot, surmounted by two cells from which arise the perithecium and the appendage. The appendage (usually broken) curved outward and upward, consisting of about ten superposed cells, the upper ones giving rise to a few branches on the inner side, which may be several times branched, the branchlets slender, mostly erect and rather rigid. Spores about 70 × 30 μ. Perithecia 120–160 × 35–45μ, the crest-like tip 38–45 μ broad, the appendage 120–325 μ. Receptacle 85–120 μ. Appendage, exclusive of branches 140–150 μ. Total length to tip of perithecium 210–290 μ.

On *Berosus striatus* Say. Kittery Point, Maine. On margin of right elytron towards the apex (invariably).

EUZODIOMYCES nov. genus.

Receptacle elongate, multicellular; consisting of a large and indefinite number of cells superposed above the single basal cell and distally becoming divided by few or many longitudinal septa; the distal portion bearing a unilateral series of perithecia and appendages. Perithecia with from nine to ten wall cells in each row, borne on a three-celled stalk.

Closely allied to *Zodiomyces*. Antheridia were not distinguished, the material being scanty and in bad condition.

Euzodiomyces Lathrobii nov. sp.

Hyaline or faintly yellowish. Receptacle long and slender, or shorter and stouter as in *Zodiomyces*, according as the longitudinal septa are few or abundant; the superposed cells and tiers of cells sometimes nearly a hundred in number, the upper half or more producing a unilateral series of perithecia and appendages. Perithecia distinctly broader distally, the fourth or the fifth to the seventh wall cells inclusive, of two opposite rows, growing upward and outward to form well developed prominences, giving the margin on either side in this region a bluntly serrate appearance; the lip-cells arched, forming a characteristic broad dome-like apex;

the two lower stalk-cells small, the upper much larger, stout, and as broad as the base of the perithecium. Appendages long slender cylindrical, simple or sparingly branched, flexuous. Perithecia $75 \times 28\text{–}30\,\mu$ (including projections), stalk about $40\,\mu$, the upper cell about $22 \times 14\,\mu$. Total length of receptacle $200\text{–}475 \times 25\text{–}70\,\mu$. Appendages $125\text{–}230 \times 4\,\mu$.

On *Lathrobium punctatum* Zett., British Museum No. 442, Notting Hill, England; on *L. multipunctatum* Grev., British Museum No. 429, Europe; on *L. filiforme* Grav. British Museum No. 443, Notting Hill, England.

PUBLICATIONS

OF THE

AMERICAN ACADEMY OF ARTS AND SCIENCES.

MEMOIRS. **Old Series, Vols. I.–IV.; New Series, Vols. I.–XII. 16 volumes, $10 each. Half volumes, $5 each. 25% discount to booksellers; 50% to members.**

Vol.	X.	Part II. *bis*	$1.75
"	XI.	" I.	2.00
"	XI.	" II. No. I.	3.00
"	XI.	" III. " II.–III.	1.00
"	XI.	" IV. " IV.	1.00
"	XI.	" IV. " V.	.75
"	XI.	" V. " VI.	.25
"	XI.	" VI. " VII.	2.00
"	XII.	No. I.	1.50
"	XII.	" II.	2.00
"	XII.	" III.	6.00
"	XII.	" IV.	1.25

PROCEEDINGS. Vols. I.–XXXIV., $5 each. 25% discount to booksellers; 50% discount to members.

Complete sets of the Memoirs, 15 vols., for $112.50, to members, $60; of the Proceedings, 34 vols. for $129, to members, $68.

Proceedings of the American Academy of Arts and Sciences.

Vol. XXXV. No. 22. — April, 1900.

CONTRIBUTIONS FROM THE PHYSICAL LABORATORY OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

XLIX. — *HISTORICAL NOTES RELATING TO MUSICAL PITCH IN THE UNITED STATES.*

By Charles R. Cross.

CONTRIBUTIONS FROM THE PHYSICAL LABORATORY OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

XLIX. — HISTORICAL NOTES RELATING TO MUSICAL PITCH IN THE UNITED STATES.

By Charles R. Cross.

Presented March 14, 1900. Received March 20, 1900.

Except in a very general way there is not much to be said regarding the early history of musical pitch in this country. The different manufacturers and musical organizations necessarily followed the usage abroad, and the same gradual rise in pitch that occurred there occurred here also.

The great harm arising from the excessive height to which the pitch had risen at the time was recognized by those interested in the procurement of the Great Organ for the Boston Music Hall, and when it was erected in 1863, it was tuned to the French pitch, $A_3 = 435$ double vibrations per second, corresponding to a tempered C_3 of 258.65 vibrations, which had been established in France four years before. It was hoped and expected that the result of this would be the gradual acceptance of the "normal diapason" as a standard throughout the United States. A second German organ, by the same maker, Walcker of Ludwigsburg, built a few years later for the First Church of Boston, was tuned to the French pitch, at which pitch it has remained up to the present time. Also in 1868, the French pitch was introduced as a standard into the public schools of Boston, by vote of the School Committee, although it never obtained a firm foothold there. Meanwhile the musical instruments in use by the various orchestras were still at the high pitch, and opera troupes and other foreign musical organizations employed the same standard. Serious difficulty was experienced from this cause, especially when the Great Organ was used in connection with an orchestra. After a time, in fact, at two separate periods, the Harvard Symphony Orchestra was furnished with instruments in accord with the organ, but apart from the concerts of this society, at theatres and else-

where, the performers were still obliged to use instruments at the high concert pitch, which naturally caused much annoyance. Moreover, the large organs built in this country during the years shortly following 1863, did not copy the example of the Music Hall Organ, and outside of Boston the French pitch was nowhere adopted. After much discussion, and not without strong opposition, it finally resulted that a decision was made to retune the Music Hall Organ, and raise the pitch to that ordinarily in use; the feeling of those who urged the change and finally prevailed being that while the lower pitch was desirable, and might be the pitch of the future in this country, they were concerned rather with the present, and might better wait the result of the efforts to introduce it abroad, which did not at first make rapid progress. The Great Organ was retuned in 1871 and remained thereafter unchanged at the high pitch $C_3 = 271$ vibrations, and tempered $A_3 = 455.8$ vibrations, until it was taken down in 1884.

No further serious attempt to lower the pitch in this country was made for a considerable time. A number of years later, however, when the French pitch had come to be quite generally adopted abroad, the subject again attracted attention here.

In 1882, Professor Eben Tourjée, then Director of the New England Conservatory of Music, determined to introduce the French pitch into that institution. For some reason, not wholly clear at the present time, the standard chosen was a C_3, a true sixth below the French A_3 and giving 261 double vibrations per second, and a fork of this pitch was constructed and adopted as a standard. The organ of the Conservatory was tuned to this pitch, and the fork continued to be used as the standard of the Conservatory until the close of 1897, when it was replaced by a new fork of 258.65 vibrations, a tempered sixth below the French A_3. The older fork had the disadvantage that an instrument tuned in equal temperament from it would differ somewhat in pitch from one tuned in the same temperament from an A_3 at French pitch, 435 vibrations.

Soon after this date several important orchestral organizations adopted a lower pitch than the one then ordinarily in use in the United States. In 1882 the orchestra of Theodore Thomas employed a sort of compromise pitch, slightly higher than the French pitch, viz.: $A_3 = 437.4$ vibrations. During the seasons 1881–2, 1882–3, the first and second of its existence, the Boston Symphony Orchestra employed a high pitch, $A_3 = 448.5$ vibrations, but in the fall of 1883 it adopted the French pitch as a standard, a procedure which speedily became general among American orchestras.

During the years preceding the installation of the Great Music Hall Organ, the pitch of organs and pianos shared in the general upward tendency, though instruments of the former class were not infrequently tuned at a somewhat lower pitch than that used by the orchestra. Cabinet organs intended for export were also in certain cases tuned to the French pitch. But the organ pitch commonly used was substantially identical with the high orchestral pitch, and that habitually used by piano manufacturers was often even higher.

The general lowering of the orchestral pitch in 1883 and the following years, of course necessitated a corresponding lowering of the pitch of pianos and organs used in concert with the orchestra, though it was a number of years before any general action was taken by the manufacturers.

In 1889 the National Music Teachers' Association at its Philadelphia meeting adopted the French pitch, and the National League of Musicians at Milwaukee, in March, 1891, also urgently recommended the adoption of this standard. For several years prior to this date the question of bringing the standard pitch used for pianos and organs into unison with the low pitch which had come to be the generally accepted pitch for orchestral use, had been agitated by a number of persons engaged in the manufacture of pianos and organs, and especially by the late Gov. Levi K. Fuller, of the Estey Organ Co., of Brattleboro, and Mr. William T. Miller of Boston. Finally at a meeting of the Piano Manufacturers' Association, held in New York, March 31, 1891, it was unanimously decided that it was desirable that a uniform pitch should be adopted in the United States, and a Committee was appointed, of which Mr. Wm. Steinway was chairman, and Gov. Levi K. Fuller, Secretary, to consider what standard should be adopted. This committee collected much evidence relating to the subject, and in response to a request therefor, received expressions of opinion from a large number of manufacturers and others interested in the determination of a standard, together with sample tuning-forks giving the pitch then in use by those sending them. The Committee reported in favor of the adoption of the A of 435 double vibrations per second as a standard of pitch, and their recommendation was adopted by the Association. It was also decided to call the newly adopted standard the "International Pitch."

The International pitch is of course identical with the French pitch, each having an A_3 of 435 double vibrations. Some confusion has arisen at times from the fact that the official standard A_3 made in 1859, and intended to represent the "diapason normal," is in fact somewhat sharper

than it purports to be, making, according to Koenig, 435.45 double vibrations per second instead of 435, when at the temperature of 15° C., and making exactly 435 vibrations only at the temperature 24.26° C. But the legal French pitch was defined by the rate 870 single vibrations, and not by the fork constructed by the Commission. Moreover the standard French forks made by Koenig were substantially correct in rate. The difference is, of course, too slight to be of any consequence in practice.

The International pitch has come to be generally adopted, so that it is now the standard pitch of this country, although it seems to be customary to tune pianos for use at concerts somewhat sharp, even up to A_3 440 vibrations, which is in fact the "Stuttgart pitch" of 1834.

At various times during the past twenty years the writer has taken the opportunity to ascertain the rates of such tuning-forks and other standards of pitch as were accessible. The results of a considerable number of these measurements were published in the "American Journal of Otology" for October, 1880, in a paper "On the Present Condition of Musical Pitch in Boston and Vicinity," by Charles R. Cross and William T. Miller. The later measurements have not hitherto been published. These have been made in part by the writer and in part by several of his assistants in the Rogers Laboratory, Messrs. Goodwin, Mansfield, Wendell, and Burgess. The present paper is intended to include such results as are likely to be of general interest.

Table I. is reprinted from the paper of Messrs. Cross and Miller. The tonometer forks available at the time of its publication were less accurate than those which have been procured subsequently, so that in certain cases, where the standards measured in 1880 were still accessible a remeasurement has recently been made, the results of which will be found in Table II. Where this has been done, it is indicated in the tables by an asterisk prefixed to the number designating the standard. By a comparison of Tables I. and II. it will be seen that the remeasurements have not materially altered the values obtained in the earlier measurements.

The standard C fork upon which the measurements of 1880 were based was a C_3 fork (No. 1 of Table I.) by Koenig, belonging to the Massachusetts Institute of Technology, the rate of which had been determined by comparison with a C_3 fork by Koenig belonging to the Stevens Institute of Technology, which last fork had been very carefully rated by Professor A. M. Mayer of that institution. The standard A used was a fork by Koenig assumed to be exact. From these the forks of an improvised tonometer were rated, the C forks being of pitch C_3 and

TABLE I.

No.	Designation.	Vibration Frequency.	Remarks.
		C_3	
*1	Koenig, physical pitch . . .	256.1	Stamped 512 *v. s.*
*2	Koenig, French pitch (approximate)	260.2	Stamped 520 *v. s.*
*3	Koenig, German pitch . . .	264.2	Stamped 528 *v. s.*
*4	Ritchie, physical pitch . . .	256.2	
5	Koenig, physical pitch . . .	256.2	Stamped 512 *v. s.*
6	Marloye, physical pitch . . .	256.4	Made between 1845–50.
7	Ritchie	259.1	Made about 1868.
8	Ritchie	259.4	" " "
*9	Ritchie, copy of Chickering's standard.	269.0	Made about 1868.
*10	Mason & Hamlin, French pitch	259.1	Used for a few years only.
11	Hutchings, Plaisted & Co . .	264.0	Low organ pitch, C_4 fork measured.
12	Hook & Hastings, old flat organ pitch	264.6	C_4 pipe measured. Temperature, 69° F.
13	Organ in church of the Immaculate Conception, Boston .	266.7	C_4 pipe measured. Temperature, 69° F.
14	Smith American Organ Co. .	267.2	C_4 fork measured.
15	New England Organ Co. . .	268.2	C_4 fork measured.
*16	Chickering's standard fork. .	268.5	C_3 fork, marked "1865, standard pitch."
*17	H. F. Miller, pianos	268.9	C_4 fork measured.
*18	Mason & Hamlin, present standard pitch	269.0	C_3 fork measured.
19	Fork of W. H. Clement, tuner.	269.2	C_4 fork measured.
20	George Woods & Co., cabinet organs	269.5	C_4 fork measured.
21	Hook & Hastings, present standard pitch	270.0	C_3 and C_4 pipes measured. Temperature, 78° F.
22	Chickering piano used at Joseffy concerts, 1880.	270.1	C_4 fork of tuner measured.
*23	Covent Garden pitch, 1879. .	270.3	C_4 fork furnished by R. Spice.
24	Weber pianos	270.8	String of piano measured.
25	Thomas' pitch	271.1	C_4 fork furnished to builders of great Cincinnati organ.
26	Music Hall organ	271.2	C_3, principal, great. Temperature 70° F.
*27	Steinway's pitch	272.2	C_4 fork furnished by R. Spice.
*28	Highest New York pitch . .	273.9	C_3 " " " "
		A_3	
29	Nichols' fork, Boston, Germania orchestra	448	Corresponding to untempered C_3, 269
*30	Marloye's A fork	426	Imported by Prof. Lovering, 1845–50.
*31	Florence pitch, Marloye. . .	438	" " "
*32	Vienna pitch, Marloye . . .	446	" " "
33	Milan pitch, Marloye	448	" " "

mostly large forks, while the A forks were the ordinary musicians' small A_3 tuning forks, tuned by the authors to convenient pitches. The same forks were used for several years subsequent to 1880.

In the recent measurements three large standards of Koenig have been used as a basis, viz.: a C_3 of 256 double vibrations, a tempered C_3 of 258.65 vibrations, and an A_3 of 435 vibrations, at a standard temperature of 20° C. From these were rated by the method of beats, a series of large C_3 forks and also two sets of C_4 small Scheibler's tonometer forks by Koenig, and two sets of A_3 forks of the same character. These small tonometer forks were also compared with a series of large Scheibler tonometer forks by Koenig, which last were assumed to be correct within the limits sought in our measurements.

Table II. gives the results of ratings of various standards of epochs indicated by the date. In all measurements later than 1891 the Koenig standard tonometer forks have been employed. The data given in Table II. are all in terms of the pitches of C_4 and A_3. The pitch of the standards actually measured is specifically stated in all cases except when it is C_4 or A_3.

Table III. contains the results of measurements of fifty-six forks sent by various manufacturers to the Committee of the National Piano and Organ Manufacturers' Association in response to their request already referred to. A preliminary rating was made by me in 1890–91 with such forks as I then possessed. The results of this were shown in a circular privately printed in 1891 for the use of members of the Association. A more exact determination was made by me a few months later in 1891, using the Koenig tonometer forks as previously stated. The results of these measurements are found in the table.

Certain of the forks and other standards referred to in Table II. deserve special mention. Those numbered 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 87, 88 were intended to give the physical pitch. Nos 2 and 3 had been in the possession of their owners for many years, and were authenticated as to the date assigned to them. Nos. 5 and 6 are two forks belonging to Harvard University, imported many years since. No. 5 is of the early Marloye pattern, with inclined prongs, but does not bear any mark to indicate the maker. No. 6 bears the mark "R. K.," always employed by Koenig. Nos. 16 and 17 are also Koenig forks of early date, belonging to Harvard University. No. 8 is a pitch pipe formerly employed for church use, belonging to Mr. B. J. Lang of Boston. It is a whistle with a movable plug, and the pitch can be varied through an octave. When the plug is set for C_4, according to the lines

TABLE II.

C_4

No.	Vibration Frequency.	Designations and Remarks.
1	506	Tonic Sol-Fa, 1882. N. E. Conservatory of Music. Rated in 1882.
2	509.7	Old Fork of J. T. Batchelder, 1782. Rated in 1884.
3	510.8	Old Fork of G. A. Emery, 1840. Rated in 1881.
4	511.1	E. S. Ritchie & Sons, Standard C_4; early fork.
5	511.5	C_3, 255.75, Marloye pattern, Harvard University.
6	511.7	C_3, 255.85, R. K.,; early fork, Harvard University.
7	511.8	C_3, 255.9, Tufts College.
8	512	Early Pitch Pipe, Maker's Standard. T = 23° C. B. J. Lang.
9	512.1	C_3, 256.05, R. K. "512 *v. s.*," slender pronged; early fork, M. I. T.
*10	512.1	C_3, 256.06, R. K. "512 *v. s.*," 1873, Basis of measurements of 1877, M. I. T.
11	512.2	C_3, 256.1, E. Greaves, "Scheibler Pitch."
12	512.2	R. K. "1024 *v. s.*," M. I. T.
*13	512.3	E. S. Ritchie & Sons, Standard C_3, 256.17.
14	512.4	E. Greaves, "Scheibler Pitch, 512."
15	512.5	W. T. Miller, 1880. Physical Pitch.
16	512.6	C_3, 256.28, R. K., "512 *v. s.*,"; early fork (prior to 1868), Harvard University.
17	512.7	R. K., C_4 "1024 *v. s.*"; early fork, Harvard University.
18	514.7	Walmsley, Fuller & Co., Chicago, 1895.
19	514.8	C_2, 128.7, E. S. Ritchie & Sons, makers, University of Virginia.
20	515.5	L. K. Fuller; electrically welded fork, 1893.
21	515.6	Tempered C_4, French Pitch, 1888. Small Fork, M. I. T.
22	516.6	"517.8 Piano Mfrs. Ass'n." New England Conservatory, 1898.
23	517.0	"Philharmonic." Tufts College.
24	517.3	Pitch Pipe, 1826, Yale University.
25	517.3	Tempered C_4, French Pitch, 1884. Small Fork. Rated in 1884.
26	517.4	Miller's Standard Tempered C_3, 258.68, 1884. Rated in 1884.
27	517.5	Tempered C_4, Small Fork, French Pitch, 1883, Boston Symphony Concerts. M. I. T.
28	517.5	C_3, 258.78, Ritchie, early fork, Marloye pattern. M. I. T.
29	517.5	Tempered C_4, French Pitch, 1884. Large fork on box. M. I. T.
30	517.6	E. S. Ritchie & Sons, C_3, 258.78, early fork, Marloye pattern. M. I. T.
31	517.7	E. S. Ritchie & Sons, C_3, 258.88; early fork. University of Virginia.
32	517.8	Chickering & Co., new tempered C_3, 258.9, French Pitch, 1884. Rated in 1884.
33	517.8	Tempered C_4, French Pitch, 1883. M. I. T.
34	518	Early Pitch Pipe. Local Pitch, T = 23° C. B. J. Lang.
*35	518.5	Mason & Hamlin, Weighted C_3, 259.24. French "Standard 1866," Pitch.
36	518.7	G. S. Hutchings, "517.8," "International Pitch."
37	519.0	C_4 Pipe giving Thomas' Pitch of 1883. T = 22° C. Hook & Hastings.

TABLE II. — *Continued.*

No.	Vibration Frequency.	Designations and Remarks.
38	519.0	C_3, 259.5. N. E. Conservatory Standard of 1882; on box. Remeasurement, 1898.
39	519.2	Do. dismounted, 259.6. Do.
40	519.6	Do. on box, 259.8. Do.
*41	520.1	C_3, 260.07. R. K. "520 *v. s.*" 1873.
42	520.4	Pitch used by Patti, 1882. L. K. Fuller.
43	520.6	G. S. Hutchings. International Pitch, C_4, natural.
44	520.6	"522, Estey Organ Co." N. E. Conservatory.
45	520.6	"N. E. Conservatory, 1892." L. K. Fuller.
46	520.8	"522, Estey Organ Co." G. S. Hutchings.
47	520.9	"International Pitch." Fork of M. Steinert & Sons Co., Boston, 1898.
48	521.4	C_3, 260.7. French Pitch, on box, N. E. Conservatory Standard of 1882. Rated, 1883.
49	521.8	C_3, 260.9. Copy of N. E. Conservatory Standard of 1882, M. I. T., on box. Rating of 1883.
50	521.8	C_3, 260.9. E. S. Ritchie & Sons, Standard C, "261."
51	522.1	True French C_4, 1883. M. I. T.
52	522.2	C_3, 261.1. Copy of N. E. Conservatory Standard of 1882. M. I. T., off box. Rating of 1883.
53	522.4	C_3, 261.1. Copy of N. E. Conservatory Standard of 1882. M. I. T., on box. Rating of 1898.
54	523.5	Theodore Thomas' Pitch, 1882, N. E. Conservatory. Rated in 1882.
55	527	Whitney & Raymond Organ Co., 1882. N. E. Conservatory. Rated in 1882.
*56	528.2	C_3, 264.11, R. K., 1873, "528 *v. s.*," German Pitch. M. I. T.
57	532.8	C_3, 266.4. Princeton University.
58	535.3	R. & M., Richmond, Va. L. K. Fuller, 1883.
59	536.0	Standard Pipe, Pitch of 1884, "540." Hook & Hastings.
60	536.3	Hazelton, L. K. Fuller, 1883.
61	536.8	Fork of period 1880. W. T. Miller.
62	536.8	Decker, L. K. Fuller, 1883.
63	536.8	C_3, 268.4. Copy of Chickering's Standard "1865." N. E. Conservatory. Rated in 1882.
*64	536.9	C_3, 268.44, Chickering Co., Standard fork, "1865." "Concert Pitch."
65	537.3	McPhail, L. K. Fuller, 1892.
*66	537.5	Miller, standard of 1880.
*67	537.9	C_3, 268.96. E. S. Ritchie & Sons, 1870. Copy of Chickering's Standard.
68	538.1	Hodge & Essex, L. K. Fuller, 1892.
*69	538.2	C_3, 269.1. Mason & Hamlin Co., "Standard Pitch, 1866."
70	538.3	Isotonic Fork, High Pitch, 1880.
71	538.6	"C, 540," Estey Organ Co. N. E. Conservatory.
72	538.9	"540," Estey & Co. G. S. Hutchings.
73	539	Chickering Concert Pitch, 1882. N. E. Conservatory. Rated in 1882.
74	539.3	"Philharmonic." L. K. Fuller, 1883.
75	539.8	E. Greaves, "540, Scheibler Pitch."
*76	540.2	"Covent Garden," 1879. R. Spice.
77	541.4	W. T. Miller, Fork of period, 1880.
78	542.5	Sanders, L. K. Fuller, 1883.
*79	544.5	Steinway, New York, 1880. M. I. T.

TABLE II. — *Continued.*

No.	Vibration Frequency.	Designations and Remarks.
80	545	Theodore Thomas' High Pitch prior to 1893. N. E. Conservatory. Rated in 1883.
81	545.1	Reed Pitch Pipe, 1885. Rated in 1885.
*82	547.7	C_3, 273.85, Highest New York Pitch, 1878. R. Spice.
83	549.0	"Philharmonic Pitch," Standard Fork of Steinert & Sons Co., 1898.
		A_3
84	415.3	A_2, 207.7 "Shore Fork," 1715. L. K. Fuller.
85	422.8	"Händel Fork," 1749. L. K. Fuller.
86	423.7	Pipe, Pitch of 1889, Hook & Hastings, T = 21.7° C.
87	426.2	A_2, 213.1, Ritchie. early fork, University of Virginia.
*88	426.5	Marloye, "853⅓." Harvard University.
89	428.8	Tufts College.
90	432.8	French A, Boston Symphony Orchestra, Henschel's original small fork, 1883.
91	433.0	Ritz, L. K. Fuller, 1883.
92	434.3	"Piano Mfrs. Ass'n." G. S. Hutchings.
93	434.5	"A, 435, Piano Mfrs. Ass'n." N. E. Conservatory.
94	434.6	"A, 435, Piano Mfrs. Ass'n." M. I. T., from L. K. Fuller.
95	434.7	E. Greaves "French Pitch."
96	434.8	R. K., French Pitch, correct at 15° C. 1888, M. I. T.
97	434.9	Electrically welded fork, L. K. Fuller, 1893.
98	434.9	R. K., A 435 at 20° C. Mason & Hamlin Standard, 1898.
99	435.0	Standard R. K., "870 *v. s.* at 20°." G. S. Hutchings.
100	435.0	R. K., A 435 at 20° C. H. F. Miller, Standard, 1891.
101	435.0	R. K., A 435 at 20° C. Chickering Co., Standard, 1898.
102	435	Pitch Pipe, 1826. Yale University.
103	435.4	Ritz. L. K. Fuller, 1883.
104	435.4	Small R. K. Fork, "870 *v. s.*," Tufts College.
105	437.4	Theodore Thomas' Pitch, 1888. M. I. T.
106	437.7	Theodore Thomas' Pitch, 1883. Georg Henschel. Rated in 1883.
107	437.8	Ritz. L. K. Fuller, 1883.
108	438.1	"French Pitch." L. Waldo, 1898.
*109	438.4	"Florence Pitch." Harvard University.
110	441.3	E. Greaves, "Scheibler Pitch," German Pitch.
*111	446.0	"Vienna Pitch." Harvard University.
112	446	Reed Pitch Pipe. Rated in 1885,
113	446.7	Carl Eichler, L. K. Fuller, 1883.
114	448.0	L. K. Fuller, 1883.
115	448.5	Boston Symphony Orchestra, Standard A, 1882–83.
116	449.1	L. K. Fuller, 1883.
117	451.5	Chickering's Pitch, L. K. Fuller, 1883.
118	454.1	W. T. Miller, 1880.
119	457.5	L. K. Fuller, 1883.
120	457.7	Steinway, L. K. Fuller, 1883.

made for the purpose, the rate is, as given in the table, 512 vibrations. Notches have been cut in certain places, apparently to give the "local pitch" used by the choir. When adjusted by these (see No. 34), the rate is 518, practically French pitch. The frequency of vibration of such a pipe is of course greatly influenced by the temperature. This pitch pipe was used in a church in West Townsend, Mass., early in the present century, and its pitch was adjusted to that in use in Boston.

No. 10 is a Koenig fork already referred to, made for the Massachusetts Institute of Technology in 1873, and used as the basis of measurements by Cross and Miller in 1880. Like all of Koenig's forks, prior to the establishment of his new standard in 1880, it is a little sharp. Nos. 11, 14, 95, 110 are forks made by Mr. E. Greaves. No. 13, the standard C_3 of E. S. Ritchie and Sons, was procured from Duboscq of Paris at a date prior to 1870. It has the inclined prongs of the Marloye forks. Nos. 19, 31, 87, are large forks made for the University of Virginia by E. S. Ritchie and Sons more than twenty-five years since. No. 24 is a pitch pipe deposited in the library of Yale University by the class of 1826, and kindly rated by Professor A. W. Wright. No. 102 is the same pipe when set to give A_3. When properly blown it gives, substantially, French pitch. No. 26 is a fork used by Miller and Sons as their standard for piano pitch in 1884. No. 29 is one of a pair of large forks on resonating boxes made in 1883, for the purpose of tuning the Chickering piano when used in the Boston Symphony Concerts, the orchestra having adopted the French pitch. It was tuned from No. 27. The firm desired to tune the piano from C rather than from A. No. 32 is a large tempered C fork, adopted in 1884 by the Chickerings for tuning pianos to be used with orchestras employing the French pitch. No. 35 is the standard French Pitch of the Mason and Hamlin Co. The fork No. 69 is lowered in pitch by attaching to each prong by wax a small rectangular piece of steel. No. 36 is a fork of G. S. Hutchings and Co., used in tuning the organs made by them. No. 37 is a flue pipe belonging to the Hook and Hastings Organ Co., and giving the pitch proposed by Theodore Thomas in 1883. Nos. 38, 39, 40 give ratings under different conditions of a large standard fork made by Ritchie and Sons for the New England Conservatory of Music in 1882. No. 48 is the same as measured in 1883. The fork has flattened by a considerable amount since its manufacture, from unknown causes. It has apparently been kept with care. The box has a considerable influence upon the pitch of the fork. No. 42 is a fork belonging to Mr. Levi K. Fuller, giving the pitch which was used in opera in 1882 by Patti. It is a little sharp of French pitch, though

far below the high pitch then habitually used in this country. No. 47 is a small fork, the standard for "International Pitch" of the M. Steinert and Sons Co., Boston. Nos. 1, 54, 55, 63, 71, 73, are forks belonging to Mr. F. W. Hale of the New England Conservatory of Music. No. 57 is an old C_3 fork belonging to Princeton University, and probably dating from the time of Prof. Joseph Henry. It is considerably rusted. No. 59 is a flue pipe giving the high pitch used by Hook and Hastings in 1884. No. 64 is the former standard fork of the Chickerings, made in 1865, and giving the high concert pitch then in vogue. It is a large C_3 fork, marked "1865, Standard Pitch," with its prongs inclined towards one another. No. 67 is a copy of the Chickering fork made by E. S. Ritchie and Sons for their own use in 1870. It has sharpened somewhat after tuning. No. 69, the Mason and Hamlin Co.'s former standard, is a large fork, almost a counterpart of the Chickering fork. It is marked "Standard Pitch, 1866." No. 76 is a small fork furnished by Mr. Robert Spice of Brooklyn, in 1879, and giving the pitch then used in the Covent Garden Theatre. No. 82 is a bell metal fork made in 1878 by Mr. Spice, and giving the highest pitch then used in New York. No. 83 is a small fork at the high "Philharmonic Pitch" of the Steinert and Sons Co.

Among the A_3 forks, No. 84 is a very old and low-pitched fork, procured by Mr. Levi K. Fuller in England, and purporting to have been made in 1715 by John Shore, the inventor of the tuning-fork, and to be the oldest fork in existence. No. 85, which also belonged to Mr. Fuller, is supposed at one time to have been used by Händel. No. 86 is a pipe giving the pitch settled upon by Hook and Hastings in 1889. Nos. 88, 109, 111 are small forks imported by Prof. Joseph Lovering for Harvard University, between 1845 and 1850. No. 90 is one of a number of small forks made for Mr. Georg Henschel in 1883 as a basis for the pitch of instruments to be made for the Boston Symphony Orchestra. It was tuned from the forks of a Valentine and Carr tonometer (see No. 3, Table V.), and owing to the extreme flatness of the "A,432" and "A,436" used in the comparison, it is considerably below French pitch. No. 96 is a standard A_3 "French Pitch," by Koenig, imported by the Massachusetts Institute of Technology in 1883. It is correct at 15° C., and hence at 20° C., the present standard temperature, is slightly flat. Nos. 98, 99, 100, 101 are large Koenig standard forks, mounted on boxes. No. 102 is the same pitch pipe as No. 24 when adjusted to give the Note A_3. Nos. 105, 106 are small forks giving the medium pitch proposed and used by Theodore Thomas in 1883. No. 106 was given to Mr. Henschel

by Mr. Thomas. No. 105 was copied from this. No. 113 is a fork giving the pitch used by the Germania Orchestra in 1883. No. 115 is a high A_3 fork, made by Mr. R. Spice, and belonging to the Massachusetts Institute of Technology, which was used by the Boston Symphony

TABLE III.

C_4 Forks.

No.	Designation.	Vibration Frequency.
1	Knabe & Co., Baltimore (Low Pitch)	508.8
2	Roosevelt Organ Co., N. Y.	516.8
3	C. B. Snyder, Winfield, Kan..	518.8
4	J. H. &. C. S. Odell, N. Y..	520.6
5	Chickering & Sons, Boston (Low Pitch)	521.8
6	J. & C. Fischer, N. Y.	526.4
7	Wilcox & White Organ Co., W. Meriden, Conn	531.6
8	Jewett & Co., Leominster, Mass.	532.8
9	Shoninger Organ & Piano Co.. New Haven, Conn. . . .	533.9
10	Gallup & Metzger, Hartford, Conn.	534.0
11	J. H. Foote, N. Y..	534.9
12	Francis Bacon, N. Y.	535.8
13	Dyer & Hughes, Foxcroft, Me.	536.1
14	A. Weber, N. Y.	536.9
15	Mason & Hamlin Organ & Piano Co., Boston	537.1
16	Vose & Sons, Boston	537.1
17	Benning & Sons, N. Y.	537.4
18	C. C. Briggs & Co., Boston	537.5
19[1]	A. M. McPhail Piano Co., N. Y.	537.8
20	Chickering & Sons, Boston (High Pitch)	538.2
21	Clough & Warren Co., Detroit	538.4
22	Atlanta Piano Co., Atlanta, Ga.	538.9
23	Geo. Steck & Co., New York	539.0
24	Wm. E. Wheelock & Co., N. Y..	539.1
25[1]	Boardman & Gray, Albany, N. Y.	539.2
26	Estey Piano Co., N. Y.	539.7
27	Decker Bros., N. Y.	539.8
28	Mehlin & Sons, N. Y.	539.8
29	R. M. Bent & Co., N. Y.	539.9
30	Pease Piano Co., N. Y.	540.0
31	A. B. Chase Co., Norwalk, Ohio	540.4
32	Newby & Evans, N. Y.	540.6
33	Knabe & Co., Baltimore (High Pitch)	540.9
34	Stirling Co., Derby, Conn..	541.8
35	Hazelton Bros., N. Y.	542.1
36	Decker & Son, N. Y.	542.1
37	Conover Bros., N. Y. . , ...	542.5
38	Sherman Clay & Co., San Francisco	545.2
39	Lester Piano Co., Philadelphia	547.1
40	Leicester Piano Co., Leominster, Mass.	549.8

[1] Forks very poor and hard to rate.

TABLE III. — *Continued.*

A_3 Forks.

No.	Designation.	Vibration Frequency.
41	P. Werlein, New Orleans, La.	431.8
42	Mason & Hamlin Organ & Piano Co., Boston	434.6
43	" " " " Philadelphia	439.3
44[1]	C. H. W. Ruhe, Pittsburg, Pa.	441.9
45[1]	Hook & Hastings, Boston	443.5
46	Clough & Warren Organ Co., Detroit	444.6
47	Kranich & Bach, N. Y.	444.6
48[1]	Geo. Jardine & Son, N. Y.	447.1
49	J. H. Foote, N. Y.	449.8
50	W. W. Kimball Co., Chicago	451.4
51	Hallet, Davis, & Co., Boston	453.2
52	Sohmer & Co., N. Y.	454.5
53	Krakauer & Bros., N. Y.	454.8
54	Steinway & Sons, N. Y.	456.0
55	Chas. M. Stieff, Baltimore	456.2
56	Keller Bros. & Blight, Bridgeport, Conn.	458.2

TABLE IV.

Forks issued in 1892 as representing "International Pitch."

A_3						C_4	
M	424.1	M	434.4	M	445.0	M	516.3
M	429.8	M	434.6	M	445.5	M	517.2
N	432.3	M	434.8	M	491.9	M	517.7
M	433.1	M	435.4	M	498.1	M	519.4
N	433.3	O	435.7			M	520.2

Orchestra as a standard in 1882–83, the year prior to the introduction of the French pitch. In the following years an exact copy of No. 96, a large Koenig A_3 435 fork mounted on a resonating box was used, which was subsequently replaced by an electrically driven fork made by Wolters of Vienna. The orchestra also possesses a Koenig A_3 fork

[1] Forks very poor and hard to rate.

mounted on a box and giving International (French) pitch, with which the last-mentioned fork can be compared.

In Table IV. are given the rates of a number of small musicians' forks loaned by Mr. L. K. Fuller, which were sold in 1892 as representing the new "International Pitch." The attached letters, M, N, O, denote the different dealers who furnished them. It will be seen that the C_4 forks range from, approximately, 516 to 520 vibrations, the true value being 517.3 vibrations, and the A_3 forks from 424 to 498 vibrations, the difference in the latter case amounting to over a major tone, and showing an extreme of carelessness in tuning and comparison that is almost incredible.

TABLE V.

Tonometer Forks. Valentine and Carr.

Designated Frequency.	Measured Frequency.				
	1	2	3	4	5
420	419.6	417.5			
424	423.6	421.5			
428	427.7	425.5			
432	431.8	429.5	429,8	430.3	
436	435.7	433.4	433.7	434.4	
440	439.8	437.5	437.4	438.3	
444	443.4	441.2	441.2	442.5	
448	447.3	445.6	445.5	446.6	
452	451.1	449.8			
456	454.9	453.3			
256			255.8	255.8	
512			511.2	511.8	512.0
516			515.4		
536			535.3		
540			539.2		539.0

Ratings have also been made of forks selected at random from several tonometers. In Table V. will be found the results of measurements upon forks from four tonometers by Valentine and Carr. The forks are all of the small pattern ordinarily used by that firm. The numerals 1, 2, 3, 4, 5, heading the corresponding columns indicate the particular set of

forks referred to. With the exception of No. 5, the tonometers are long range ones, running from C_3 to C_4. No. 5 is a short range tonometer of 12 forks, from 512 to 544 vibrations, purchased by the Massachusetts Institute of Technology, in 1882. No. 1 belonged to Mr. Levi K. Fuller and was purchased by him in 1892. No. 2 was made for the Massachusetts Institute of Technology in 1882. No. 3 refers to the same tonometer. The values under (2) were obtained by comparison of the forks with those of (1). The values under (3) were obtained by direct comparison with Koenig's forks, as were all the results in Table V. except those under (2). No. 4 is a tonometer belonging to Harvard University, and which was purchased by Professor Lovering about 1883. The forks taken for comparison were A_3 and C_4 forks. It will be seen that the error is in some cases very considerable, amounting for some of the A_3 forks to several vibrations.

The small tonometer forks of Koenig are usually closely in accord with his large standard and tonometer forks, not often deviating from the numbers stamped upon them by as much as one tenth of a double vibration.

In all the measurements referred to in the present paper time-intervals were measured by the use of an accurate stop-watch reading to one-fifth of a second.

Rogers Laboratory of Physics,
March, 1900.

PUBLICATIONS

OF THE

AMERICAN ACADEMY OF ARTS AND SCIENCES.

MEMOIRS. OLD SERIES, Vols. I.–IV.; NEW SERIES, Vols. I.–XII. 16 volumes, $10 each. Half volumes, $5 each. 25% discount to booksellers; 50% to members.

Vol.	X.	Part II. *bis*			$1.75
"	XI.	"	I.		2.00
"	XI.	"	II	No. I.	3.00
"	XI.	"	III.	" II.–III.	1.00
"	XI.	"	IV.	" IV.	1.00
"	XI.	"	IV.	" V.	.75
"	XI.	"	V.	" VI.	.25
"	XI.	"	VI.	" VII.	2.00
"	XII.	No.	I.		1.50
"	XII.	"	II.		2.00
"	XII.	"	III.		6.00
"	XII.	"	IV.		1.25

PROCEEDINGS. Vols. I.–XXXIV., $5 each. 25% discount to booksellers; 50% discount to members.

Complete sets of the MEMOIRS, 15 vols., for $112.50, to members, $60; of the PROCEEDINGS, 34 vols. for $129, to members, $68.

Proceedings of the American Academy of Arts and Sciences.

Vol. XXXV. No. 24. — May, 1900.

SUPPLEMENTARY NOTE ON THE CHIEF THEOREM OF LIE'S THEORY OF FINITE CONTINUOUS GROUPS.

By Stephen Elmer Slocum.

CONTRIBUTIONS FROM THE GRAY HERBARIUM OF HARVARD UNIVERSITY, NEW SERIES, NO. XIX.

By M. L. Fernald.

Presented by B. L. Robinson, March 14, 1900. Received April 19, 1900.

I.—A SYNOPSIS OF THE MEXICAN AND CENTRAL AMERICAN SPECIES OF SALVIA.

In his monograph of the *Labiatae* in De Candolle's Prodromus, Bentham (1848) recognized 118 species of *Salvia* in Mexico and Central America, several of them, however, being known only from the original descriptions.

In the botanical portion of Biologia Centrali-Americana, Mr. Hemsley enumerated 135 species, but a number of them were unknown to him, seven have proved to be identical with others there listed, and the records of two are based upon their occurrence in adjacent portions of the United States but not in Mexico proper. Thus excluding these nine species, there were recorded by Mr. Hemsley, in 1887, 126 Mexican and Central American Salvias.

During the past quarter century the unprecedented activity in the botanical exploration of those countries has brought together in *Salvia*, as in many other large genera, an abundance of material for study. Many of these recent collections have been critically examined, and a large number of species based upon them have been described. The collections of the past decade, furthermore, contain very many unique plants which cannot be referred to any of the species already published. These species, together with those described in the last half-century, since the publication of Bentham's treatment of the group in the Prodromus, increase the number of known Mexican and Central American Salvias by nearly one hundred.

In order to place before students of Mexican botany many previously undescribed forms and to show more clearly than could otherwise be done their affinities, a synopsis has been prepared of all the known Mexican and Central American species. In the preparation of this work the general divisions of Bentham have been adopted, though with

more material at hand it has been necessary in many cases to amplify or alter the limits of groups as defined by him.

It was hoped that the treatment of the genus published by M. le Professeur Jean Briquet in "Engler & Prantl's Natürlichen Planzenfamilien"[1] would be of assistance in preparing this synopsis; but, except for the introduction of somewhat helpful minor divisions of the groups, that work adds little to the earlier conclusions of Bentham. In fact, so far at least as the Mexican species are concerned, Professor Briquet's translations of Bentham's sectional and subsectional diagnoses are most unfortunate, often so far so as quite to contradict the true characters of the plants he is supposed to be describing, and entirely to mislead the student who attempts to follow his synopsis. In the description of the very first group, the § *Micranthae*, for example, Bentham says: "Corolla vix 3-linearis calyce *dimidio vel rarius subduplo longior*" (corolla about 3 lines long, once and a half or rarely almost twice as long as the calyx), proportions which are maintained almost without exception by the species of that section. Yet this is rendered by Briquet "Blkr. [Blumenkrone] klein, *die Hälfte der Länge des Kelches erreichend, seltener* 2 *mal grösser*" (corolla small, half the length of the calyx, rarely twice longer) although the species which constitute the section have the corolla as defined by Bentham. Briquet's description of the § *Microsphaceae*, included by Bentham in the Prodromus under § *Micranthae*, reads: "Blkr. klein, *kaum die Hälfte der Länge des Kelches erreichend*" (corolla small, scarcely half as long as the calyx), thus suggesting plants with the calyx definitely exceeding the corolla, instead of the species, enumerated by him, with the corolla distinctly exceeding the calyx. Again in the § *Brachyanthae* Bentham describes the lower lip of the corolla as follows: "labium patens . . . *galea longius*" (lip spreading . . . longer than the galea), while Briquet, rendering it into German says ". . . ausgebreiteter Unterlippe, diese *nicht* länger als die Oberlippe" (. . . the spreading lower lip, this not longer than the upper lip [galea]), thus absolutely contradicting the character of the corolla as shown by the species included by him in the section.

Of the 217 Salvias recognized in the present paper, specimens — or in seven cases merely authentic plates — of 174 species have been examined. Of the remaining 43 species very many, although well described, were unknown to Bentham and have not been identified with recently collected material. Others recognized by Bentham as of doubt-

---

[1] Engl. & Prantl, Nat. Pflanzenf. iv. Ab. 3, 270–286.

ful status are here noted, although they are so incompletely characterized as to make their identification without access to the types quite impossible. In such cases the traditional conception of the plant has been maintained as far as possible, though it is highly probable that future study of these little-known types will identify some of them with better known species.

The descriptions of two species recently published from old manuscripts contain so little of specific significance that it is impossible to say upon what plants they were based. These are *S. azurea* and *S. dichroma*, La Llave in La Naturaleza, vii (1885) Apend. 82.

A European species, *S. Sclarea*, L., is often cultivated in central Mexico and is sometimes distributed in exsiccatae as if an indigenous plant (for example, see Schaffner's no. 49 from the mountains of San Luis Potosi).

In the study of species of § *Membranaceae* Mr. N. E. Brown of the Royal Gardens at Kew has rendered very valuable service by comparing specimens submitted to him with the types of Bentham's species.

SYNOPSIS OF SPECIES.

(As far as possible the sectional numbers and descriptions have been maintained as given in the Prodromus.)

Section VII. CALOSPHACE, Benth. Calyx ovate, tubulose or campanulate, the upper lip entire or shortly tridentate, the teeth approximate, and the middle one longest. Corolla-tube exserted or included, not annulate within, but occasionally furnished with 2 teeth near the base. Upper lip (galea) straight or concave, entire or often short-emarginate; the lower with spreading lobes. Anterior portion of the connective deflexed, linear, longitudinally connate or approximate, occasionally a little dilated, and rarely bearing an empty adnate anther-cell.

§ 1. MICRANTHAE, Benth. Bracts small, mostly deciduous. Corolla blue or white, short, 8 mm. or less (in one species nearly 1 cm.) in length, very slightly or rarely almost twice exceeding the calyx; the tube generally ventricose; the galea straight.

* Corolla very small, 3 to 5 mm. long: calyx glandular.

+ Calyx-lobes blunt.

1. S. OCCIDENTALIS, Swartz, Fl. Ind. Occ. i. 43; Benth. l.c. 296; Gray, Syn. Fl. ii. pt. 1, 370; Hemsl. l. c. 562; Briq. l. c. 277. *S. procumbens*, Ruiz & Pav. Fl. Per. & Chil. i. 27, t. 39, fig. a. *S. radicans*, Poir. Dict. vi. 621. *Verbena minima chamaedryos folio*, Sloane, Jam. i.

172, t. 107. *Hyptis glandulosa*, Sieb. Fl. Mart. Exs. no. 151, fide Benth. l. c. — Common in tropical and subtropical America, extending north to Vera Cruz. Vera Cruz, Mt. Orizaba (*Botteri*, no. 394); Cordoba (*Asa Gray*): Yucatan, waste ground near Merida, April, 1887 (*Porfirio Valdez*, no. 55): Guatemala, Coban, Dept. Alta Verapaz, alt. 1,320 m., Nov. 1886 (*H. von Tuerckheim* in exsicc. J. D. Smith, no. 1090); Santa Rosa, alt. 770 to 920 m., May, Dec., 1892 (*Heyde & Lux* in exsicc. J. D. Smith, nos. 3014, 4399): Honduras, San Pedro Sula, Dept. Santa Barbara, alt. 250 m., May, 1888 (*C. Thieme* in exsicc. J. D. Smith, no. 5422): Nicaragua (*Charles Wright*): Costa Rica, Ujaras (*Oersted*); Cartago, alt. 1,300 m., Dec., 1887 (*Juan J. Cooper*) in exsicc. J. D. Smith, no. 5901; roadsides San José, Jan., 1893 (*Ad. Tonduz*, no. 7280).

+ + Calyx-lobes subulate-mucronate.

++ Bracts deciduous.

2. S. misella, HBK. l. c. 290; Benth. l. c. 297; Hemsl. l. c. 561; Briq. l. c. — Described from near Acapulco: perhaps the same as the next.

++ ++ Bracts persistent.

3. S. obscura, Benth. Lab. 245, & in DC. l. c. 297; Millspaugh, Field Columb. Mus. Bot. ser. i. 43. *S. privoides*, Gray, Syn. Fl. l.c. 371, not Benth. *S. occidentalis*, Millsp. l. c., in part, not Swartz. *S. occidentalis*, var.? *Garberi*, Chapm. Bot. Gaz. iii. 10. — Range similar to that of *S. occidentalis*, extending north to Sinaloa and Lower California. Lower California, La Paz, 1890 (*Edw. Palmer*, no. 10): Sinaloa, Mazatlan, Dec., 1894 (*F. H. Lamb*, nos. 311, 317): Guerrero, Acapulco, 1895 (*Edw. Palmer*, no. 244): Vera Cruz, Valley of Cordova, Dec. 18, 1865 (*Bourgeau*, no. 1504): Yucatan, roadside, near Izamal, Jan. 14, 1895 (*Millspaugh*, no. 90); Island of Cozumel, 1895 (*G. F. Gaumer*, no. 394).

* * Corolla 6 to 8 mm. long.

+ Calyx glandular.

++ Bracts caducous.

= Stem villous: leaves ovate-lanceolate, rufous-tomentose beneath: verticels 4–6-flowered: calyx with obtuse lobes.

4. S. inconspicua, Benth. Lab. 247, & in DC. l. c. 298; Hemsl. l. c. 558; Briq. l. c. 278. — Described from Mexico. Not seen.

= = Stem pubescent with long spreading gland-tipped hairs: leaves broad-ovate, slightly puberulent beneath: verticels 2-flowered: calyx with acuminate lobes.

5. S. podadena, Briq. Ann. Conserv. Jard. Bot. Genève, ii. 131. — Described from Oaxaca. Not seen.

+ + Bracts persistent.

= Leaves villous or long-pilose beneath.

a. Leaves canescent on both faces, 1 to 3 cm. long, on slender naked petioles: calyx-lobes acutish.

6. S. SEROTINA, L. Mant. 25; Jacq. Ic. Rar. i. 1, t. 3; Benth. l. c.; Hemsl. l. c. iv. 107; Briq. in Engl. & Prantl, l. c. *S. dominica*, Vahl. Enum. i. 233; Swartz, Obs. 18, t. 1. fig. 1, not L. — Florida and the West Indies. Reported from Cozumel Island, YUCATAN.

b. Leaves ferrugineous-villous beneath, 1 dm. or less long, cuneate to winged petioles: calyx-lobes setaceous-mucronate.

7. S. PRIVOIDES, Benth. Bot. Sulph. 150, & in DC. l.c. 297; Hemsl. l. c. ii. 563; Briq. l. c. — Southern Mexico and Central America. JALISCO, Guadalajara, Sept., 1886 (*Edw. Palmer*, no. 498); cool shady places, barranca near Guadalajara, Nov. 5, 1888 (*C. G. Pringle*, no. 1727); San Sebastian, alt. 1,185 to 1,540 m., March 16, 1897 (*E. W. Nelson*, no. 4072): MORELOS, Cuernavaca, Nov. 14, 1865 (*Bourgeau*, no. 1239): OAXACA, Jayacatlan, alt. 1,320 m., Sept. 10, 1894 (*L. C. Smith*, no. 174).

= = Leaves short-pilose or glabrate beneath.

a. Inflorescence an oblong raceme, 4 to 7 cm. long, not secund: calyx tubulose-campanulate, in fruit 7 mm. long.

8. S. MICRANTHA, Vahl. Enum. i. 235; Benth. l. c. 298; Hemsl. l. c. 561; Briq. l. c. *S. bullata*, Ort. Dec. ix. 109; Jacq. Hort. Schoenb. iv. 41, t. 481. *S. serotina*, Vahl. l. c. 232, not L. *S. occidentalis*, Millsp. l. c. in part, not Swartz. — Tropical America, in Mexico known only from the Yucatan coast. YUCATAN, streets of Dolores, Island of Mugeres, Jan. 1, 1895 (*Millspaugh*, no. 18); without locality, 1896 (*Porfirio Valdez*, no. 31). *S. orbicularis*, Benth. Bot. Sulph. 151, from Panama seems to differ from the species only in its fruticose base.

b. Inflorescence secund, loosely-flowered.

1. Calyx-tube bearing long straight spreading setiform glandless hairs mixed with the shorter gland-tipped ones; upper lip entire: racemes simple, elongated, becoming 1 to 1.5 dm. long.

9. **S. setosa.** Annual, 2 to 5 dm. high; the stems slightly appressed-retrorse-setulose on the angles: leaves ovate or rhombic-ovate, thin, acute or blunt at tip, cuneate at base to winged petioles, crenate-serrate, 8 cm. or less in length, sparingly appressed-setulose above, paler and minutely puberulent or glabrate beneath: racemes stiff; verticels mostly 2-flowered, all becoming remote, the lowest 1.5 to 2.5 cm. apart: bracts

lance-subulate, 5 to 7 mm. long: pedicels 2 to 4 mm. long: calyx in anthesis 5 mm., in fruit 9 mm. long; the lobes equalling the tube, narrow-ovate, with long subulate aristiform tips, the pubescence less spreading than on the tube: corolla 7 to 8 mm. long; the sparingly pilose lips deep blue. — *S. privoides*, Gray in Wats. Proc. Am. Acad. xxi. 435; Rose, Contrib. U. S. Nat. Herb. i. 110; not Benth. — Northwestern Mexico. CHIHUAHUA, Hacienda San José, 1885 (*Edw. Palmer*, no. 64): SONORA, by shaded water-courses and in cañons, Alamos, Sept., 1890 (*Edw. Palmer*, no. 680, 681).

2. Calyx pubescent with gland-tipped hairs; upper lip generally tridentate: racemes paniculate, 5 cm. or less in length.

10. **S. lateriflora.** Bushy-branched annual, 2.5 to 3 dm. high: stems sparingly retrorse-pilose: leaves ovate or rhombic-ovate, thin, blunt or acutish at tip, cuneate to slender petioles 5 cm. or less long, coarsely crenate-dentate, minutely setulose on both faces or glabrate: flowers solitary or in 2's, all remote, the lowest 0.7 to 1 cm. apart: bracts ovate, acuminate, 1 to 2 mm. long: pedicels 2 to 4 mm. long: calyx in anthesis 2 to 3 mm., in fruit 5 to 6 mm. long; the tube twice exceeding the broad blunt subulate-tipped lobes. — SONORA, about abandoned gardens, Guaymas, Oct., 1887 (*Edw. Palmer*, no. 320). Habitally resembling *Scutellaria lateriflora*. A fragmentary specimen collected by *Xantus* at Cape St. Lucas, LOWER CALIFORNIA, may belong here.

+ + Calyx not glandular.

++ Leaves thin, membranaceous, the primary ones 4 to 9 cm. long: verticels 6–many-flowered.

11. S. TILIAEFOLIA, Vahl. Leaves broad- or rhombic-ovate, cordate truncate or rounded-cuneate at base, sparingly pubescent on both faces, dark green above. — Symb. iii. 7; Jacq. Hort. Schoenb. iii. 2. t. 254; Benth. l. c. 299; Hemsl. l. c. 566. *S. fimbriata*, HBK. l. c. 299, t. 149. — Common in tropical America, extending northward through Mexico. CHIHUAHUA, Valley of Chihuahua, Sept. 17, 1885 (*C. G. Pringle*, no. 556; damp places, Cañon de Pilares, Sept. 22, 1891 (*C. V. Hartman*, no. 749): COAHUILA, Saltillo, 1848–49 (*J. Gregg*, no. 542); Soldad, Sept., 1880 and in shaded places, Saltillo, Sept., 1880, 1898 (*Edw. Palmer*, nos. 1062, 335): DURANGO, abundant in shade near Durango, Sept., 1896 (*Edw. Palmer*, no. 572): SAN LUIS POTOSI, in deep shade near the city, 1876 (*Schaffner*, no. 674), alt. 1,850 to 2,460 m., 1878 (*Parry & Palmer*, nos. 743, 746½): AGUAS CALIENTES (*Hartweg*, no. 159): MEXICO, Valley of Mexico, May 5, 1865 (*Bourgeau*, no.

122): VERA CRUZ, Orizaba (*Botteri*, nos. 533, 869), Aug. 13, 1891 (*Seaton*, no. 304); Cordoba (*Asa Gray*): OAXACA, Monte Alban, alt. 1,900 m., Oct. 11, 1895 (*L. C. Smith*, no. 949): GUATEMALA, Santiago, Dept. Zacatepéquez, alt. 2,000 m., 1891 (*Rosalía Gomez* in exsicc. J. D. Smith, no. 816); Castillas, Dept. Santa Rosa, alt. 1,230 m., Sept., 1892 (*Heyde & Lux* in exsicc. J. D. Smith, no. 4055): COSTA RICA, Cartago, alt. 1,300 m., Nov., 1888 (*Juan J. Cooper* in exsicc. J. D. Smith, no. 5900); San José, July, 1892, and San Francisco de Guadalupe, Dec., 1893 (*Ad. Tonduz*, nos. 701, 8456). See note under *S. Chia*. *S. flexuosa*, Presl in Benth. Lab. 248, is perhaps only a glabrate form of this species, apparently represented by *Botteri's* no. 395 from Orizaba.

Var. **cinerascens**. Whole plant cinereous with fine puberulence. — JALISCO, barranca near Guadalajara, Oct. 3, 1891 (*C. G. Pringle*, no. 5176).

++ ++ Leaves firm, small, 1 to 2.5 cm. long: verticels 2–4-flowered.

= Herbaceous, erect: leaves broad-ovate, cordate, minutely pubescent: lower verticels in axils of upper foliar leaves.

12. S. HUMILIS, Benth. Lab. 247, & in DC. l. c. 298; Hemsl. l. c. 558; Briq. l. c. — Described from "Mexico." Not seen.

= = Diffusely branching from woody base: leaves narrowly rhombic-ovate, or oblong-ovate, cuneate, densely pilose-setulose beneath: racemes short-peduncled.

13. **S. pusilla.** Stems 1 to 2.5 dm. long, slender and wiry, puberulent and hoary with fine spreading setulose hairs; more or less diffusely branched: leaves blunt or acutish, irregularly more or less serrate, green above, pale beneath, long-setulose on both faces or glabrate above, on short slender petioles: peduncles 1.5 to 4 cm. long: racemes 1 to 8 cm. long; the verticels all remote, the lowest becoming 2 to 2.5 cm. apart: bracts ovate, 3 to 4 mm. long, firm and essentially persistent: pedicels very short: calyx white-setulose, in anthesis 2 to 3 mm., in fruit 5 mm. long; the tube once and a half longer than the acuminate lobes: corolla blue, 7 mm. long; the tube short-exserted; the pilose galea twice exceeded by the lip: style densely bearded. — OAXACA, vicinity of Yalalag, alt. 1,230 to 2,400 m., July, 1894 (*E. W. Nelson*, no. 958); Sierra de San Felipe, alt. 2,160 m., Sept. 23, 1895 (*C. Conzatti*, in exsicc. L. C. Smith, no. 708).

* * * Corolla 9 to 10 mm. long.

+ Leaves cuneate or rounded-cuneate at base: calyx subglabrous.

++ Leaves oblong-lanceolate.

14. S. OUROPHYLLA, Briq. Ann. Conserv. Jard. Bot. Genève, ii. 126. — Described from COSTA RICA. Not seen.

++ ++ Leaves ovate or ovate-elliptic.

15. S. PERMIXTA, Briq. l. c. 129. — Described from COSTA RICA. Not seen.

+ + Leaves hastate at base: calyx glandular.

16. S. COSTARICENSIS, Oersted in Kjoeb. Vidensk. Meddel. (1853) 39; Hemsl. l. c. 555. — COSTA RICA, Cartago, alt. 1,300 m., Dec., 1887 (*Juan J. Cooper* in exsicc. J. D. Smith, no. 5895); San José, Oct., 1892 (*Ad. Tonduz*, no. 7158).

§ 2. MEMBRANACEAE, Benth. Flowers as in the *Micranthae* or a little larger. Bracts suborbiculate, persistent, membranaceous, veiny, equalling or exceeding the calyx.

* Leaves narrow-ovate, cuneate or narrowed at base.

+ Calyx glabrous, subtruncate, with very short teeth: verticels approximate, forming a spiciform raceme 4 to 8 cm. long: bracts and calyces blue or roseate.

17. S. LOPHANTHA, Benth. in DC. l. c. 301; Hemsl. l. c. 560, in part; Briq. in Engl. & Prantl, l. c. — GUATEMALA, Santa Rosa, alt. 1,230 m., Oct., 1892 (*Heyde & Lux* in exsicc. J. D. Smith, no. 4051).

+ + Calyx pubescent.

++ Calyx canescently short-pilose, not viscid: verticels remote, forming a raceme 1 to 2.5 dm. long.

18. S. MOCINOI, Benth. Lab. 271, & in DC. l. c. 300; Hemsl. l. c. 561; Briq. l. c. — GUATEMALA, Laguna de Ayarza, Dept. Jalapa, alt. 2,460 m., Sept., 1892 (*Heyde & Lux* in exsicc. J. D. Smith, no. 4048).

++ ++ Calyx viscid, short-pilose.

= Branches pilose; the hairs spreading.

a. Racemes simple, or very slightly branched; verticels tending to become remote; the primary racemes becoming 0.8 to 2 dm. long: lowest bracts crenate-serrate.

19. S. RUBIGINOSA, Benth. l. c. 301. Mature leaves pubescent beneath only on the nerves. — Hemsl. l. c. 565; Briq. l. c. *S. lophantha*, Donnell Smith, Enum. Pl. Guat. ii. 62, not Benth. *S. Mocinoi*, Donnell Smith, l. c. iv. 125, 188, in part, not Benth. — Southern Mexico and Central America. GUATEMALA, Pinula, alt. 1,350 m., Feb., 1890 (*J. D. Smith*, no. 1911); Chiapas, Dept. Santa Rosa, alt. 1,080 m., Dec., 1892 (*Heyde & Lux* in exsicc. J. D. Smith, no. 4400).

Var. **hebephylla.** Leaves velutinous beneath. — *S. lophantha*, Hemsl. l. c. 560, in part, not Benth. — VERA CRUZ, region of Orizaba, Oct. 11, 1866 (*Bourgeau*, no. 3215): CHIAPAS, among the mountains (*Ghiesbreght*, no. 745): GUATEMALA, Volcan Fuego, Zacatepéquez, alt. 1,540 m., March, 1892 (*J. D. Smith*, no. 2597).

b. Inflorescences paniculate; all the verticels remote: bracts entire.

20. **S. cladodes.** Stems glabrate below, sordid-pilose above: leaves oblong to narrow-ovate, 1 dm. or less long, 5 cm. or less wide, long-acuminate at tip, cuneate at base, finely crenate-serrate, short-velutinous or glabrate on both surfaces; petioles 2 cm. or less long: panicle with slender ascending densely pilose branches 1 to 2 dm. long: bracts purplish, broad-ovate or suborbicular, acuminate, more or less pilose, ciliate: verticels 1 to 2.5 cm. apart, 3–9-flowered; pedicels 4 to 7 mm. long, spreading and nodding at tips: calyx purplish, in anthesis 8 to 9 mm. long, broadened upward; the tube glandular-pilose; the glabrate limb with ovate-acuminate lobes: corolla-tube included; the lips one half longer than the calyx. — Northwestern Mexico. Without locality (*Seemann*): TEPIC, near Compostela, alt. 1,540 to 1,850 m., Apr. 7–8, 1897 (*E. W. Nelson*, no. 4171).

= = Branches canescent with appressed strongly recurved hairs: only the lowest verticels remote, the spiciform racemes 1 to 6 cm. long: bracts entire or undulate, ciliate.

21. **S. saltuensis.** Stems 1 to 1.5 m. high, bearing solitary terminal racemes or many inflorescences of 1 to 3 verticels on short leafy branchlets: leaves 6 cm. or less long, acute, finely crenate-serrate, dull green and finely pubescent above, canescent-tomentulose beneath, on slender petioles 1.5 cm. or less in length: bracts reniform, acuminate, brownish or slightly rosy tinged, minutely pubescent on the nerves, 1 to 1.5 cm. long: calyx purple-tinged, appressed-hirsute, in anthesis 7 mm. long, with broad blunt or short-acuminate lobes: corolla 1.3 cm. long, blue, the pilose galea one half as long as the lip. — MORELOS, in woods of Sierra de Tepoxtlan, alt. 2,310 m., Feb. 8, 1899 (*C. G. Pringle*, no. 8035): JALISCO, between San Sebastian and the summit of Mt. Bufa de Mascota, alt. 1,380 to 2,300 m., March 20, 1897 (*E. W. Nelson*, no. 4103).

= = = Of close affinity to the preceding is

22. S. BUPLEUROIDES, Presl in Benth. Lab. 271, a glabrous plant with fascicled peduncles each bearing solitary many-flowered verticels. Not identified.

* * Leaves broad-ovate (narrow-ovate in *S. nitida*) or rhombic-ovate, rounded to the subcordate truncate or subcuneate base.

+ Verticels remote (approximate in a form of *S. hyptoides*): leaves 5 cm. or less in length.

++ Leaves glabrous or only minutely puberulent.

= Leaves ovate-lanceolate, glossy.

23. S. NITIDA, Benth. in DC. l. c. 300; Hemsl. l. c. 562; Briq. l. c. *Hyptis nitida*, Mart. & Gal. Bull. Acad. Brux. xi. pt. 2, 189. — Described from OAXACA. Not seen.

= = Leaves rhombic-ovate, dull.

24. **S. galinsogifolia.** Stems 1.5 to 6 dm. high, branching, minutely puberulent, the young parts canescent: leaves 5 cm. or less in length, blunt or acutish, minutely and sparingly puberulent or glabrous, the lowest shorter than the slender petioles: peduncles 1.5 dm. or less in length; verticels from 1 to 5, the lowest becoming 3 to 5 cm. apart; rhachis canescent: bracts reniform, short acuminate, pale-brown or roseate-tinged, puberulent, ciliate-margined: calyx white-villous, with bluntish ovate-lanceolate lobes: corolla 8 to 9 mm. long, puberulent; the galea thrice exceeded by the lip. — *S. hyptoides*, Gray in Wats. Proc. Am. Acad. xxi. 435; Rose, Contrib. U. S. Nat. Herb. i. 110; not Mart. and Gal. — Northwestern Mexico. CHIHUAHUA, Hacienda San Miguel, 1885 (*Edw. Palmer*, no. 205): SONORA, in shade, mountain-cañon, Alamos, Sept., 1890 (*Edw. Palmer*, no. 682); Huehuerachi, alt. 1,230 m., Dec., 1890 (*C. V. Hartman*, no. 323, *F. E. Lloyd*, no. 452). Resembling *S. hyptoides*.

+ + Leaves setulose-hirsute.

= Calyx white-lanate, with short deltoid lobes.

25. S. LASIOCEPHALA, Hook. & Arn. Bot. Beech. 306; Benth. l. c.; Hemsl. l. c. 559; Briq. l. c. — TEPIC, Tepic (the type station), Feb., 1895 (*F. H. Lamb*, no. 621).

= = Calyx-tube hirsute; lobes lanceolate.

26. S. HYPTOIDES, Mart. & Gal. l.c. 74; Benth. l.c.; Hemsl. l.c. 558; Briq. l. c. *S. elsholtzioides*, Benth. Bot. Sulph. 152, t. 50. — Southern Mexico to Venezuela. JALISCO, bluffs of the Rio Grande de Santiago, near Guadalajara, Oct. 19, 1889 (*C. G. Pringle*, no. 2297): VERA CRUZ, Jalapa, alt. 1,230 to 1,390 m., 1894 (*C. L. Smith*, no. 1664): OAXACA, dry banks, Sierra de San Felipe, alt. 2,160 m., Oct. 11, 1894 (*C. G. Pringle*, no. 5624); Jayacatlan, alt. 1,320 m., Nov. 4, 1894 (*L. C. Smith*, no. 269); El Fortin, alt. 520 m., 1897 (*C. Conzatti & V. González*, no. 478): GUATEMALA, Coban, Dept. Alta Verapaz, alt. 1,320 m., March, 1886 (*H. von Tuerckheim* in exsicc. J. D. Smith, no. 299); Jumaytepeque, Dept. Santa Rosa, alt. 1,850 m., Sept., 1892 (*Heyde & Lux*, in exsicc. J. D. Smith, no. 4047: COSTA RICA, Volcan el Viejo (*Oersted*).

Var. **subspicata.** Plant simple, 1 to 2 dm. high: verticels 2 to 5,

approximate in a spiciform raceme 1 to 3.5 cm. long, or the lowest a little remote. — COSTA RICA, near San Francisco de Guadalupe, Jan. 4, 1893 (*Ad. Tonduz*, no. 7228).

+ + Verticels approximate in a spiciform raceme: principal leaves 6 to 8 cm. long.

27. **S. lophanthoides.** Stem tall, 1 m. or so high, glabrous, or minutely pilose at the tip; internodes 1 to 2 dm. long: leaves broad-ovate, short-acuminate, glabrous above, villous beneath on the nerves, and especially along the midrib, finely crenate-serrate, on slender petioles 3 cm. or less in length: peduncles 1.5 cm. or less long; racemes dense, the primary ones 1.3 dm. or less in length, 1.5 cm. thick: bracts brownish, ciliate-margined: calyx viscid, pilose on the strong nerves, in anthesis 5 to 6 mm. long, slightly enlarged at the throat, with broad-deltoid subulate-tipped lobes: corolla blue, slightly viscid, 1.2 to 1.4 cm. long, the lip twice exceeding the galea. — OAXACA, mountains near Tlapancingo, alt. 1,850 to 2,460 m., Dec. 7, 1894 (*E. W. Nelson*, no. 2086).

§ 3. BRACHYANTHAE, Benth. Bracts small, after anthesis falling away, rarely persisting. Corolla middle-sized, conspicuously exceeding the calyx, 1 to barely 2 cm. long (rarely longer), generally blue, very rarely white flesh colored or crimson, never scarlet, with the tube generally ventricose and often contracted at the throat; with straight or scarcely arched galea (upper lip), and broader 3-lobed lower lip generally exceeding the galea, the middle lobe broadest and emarginate. (Species with exceptionally large flowers, but with their affinities here are *S. heterotricha*, *S. flaccida*, *S. cedrosensis*, *S. semiatrata*, and *S. sidaefolia* with corollas fully 2 cm. long; *S. angustifolia* with corolla 2.5 cm. long; and *S. sessilifolia* with corolla 3 cm. long.)

A. Angustifoliae, Benth. Leafy-stemmed herbs or half-shrubs with slightly branching stems: leaves linear, lanceolate, or narrowly ovate-elliptic, narrowed cuneate or rounded-truncate at base.

* Bracts orbicular, acuminate, about equalling the calyx, persistent: verticels becoming remote: calyx campanulate, green, strongly nerved, subinflated, becoming 1 cm. long, the broad upper lip suberect. Erect annual 2 to 4 dm. high.

28. S. HIRSUTA, Jacq. Hort. Schoenb. iii. 1, t. 252; Benth. in DC. Prodr. xii. 301; Hemsl. l. c. 557; Briq. in Engl. & Prantl, l. c. 278. *S. phlomoides*, Cav. Ic. iv. 10, t. 320. *S. ciliata*, Poir. Dict. vi. 588. *S. bracteata*, Poir. l. c. 622. *S. sideritidis*, Vahl, Enum. i. 250. *S. cryptanthos*, Schultes, Obs. 12, acc. to Benth. *S. nepetifolia*, Poir. Suppl. v. 48. *S. ciliaris*, Sessé & Moc. Pl. Nueva España, ed. 2, 7. —

Central Mexico. DURANGO, infrequent on shady slopes of ravines, Santiago Papasquiaro, Aug., 1896 (*Edw. Palmer*, no. 451): SAN LUIS POTOSI, alt. 1,850 to 2,460 m., 1878 (*Parry & Palmer*, no. 736): MEXICO, barranca near Santa Fé, July 6, 1865–66 (*Bourgeau*, no. 490); Santa Fé, Sept. 3, 1899 (*C. G. Pringle*, no. 7991).

* * Bracts less conspicuous, soon deciduous: calyx campanulate, conspicuously bilabiate, subinflated.

+ Leaves sessile or subsessile or narrowed to short inconspicuous petioles: racemes elongated, at least the lower verticels becoming remote: perennials. (*S. assurgens* may be looked for here.)

++ Stems leafy nearly or quite to the inflorescence.

= Without glandular hairs on stem and calyx.

29. S. ANGUSTIFOLIA, Cav. Stems hispid, bearded at the nodes, 2 to 7 dm. high, very leafy: leaves mostly hispid on the margins and nerves — Ic. iv. 9, t. 317; Lindley, Bot. Reg. xviii. t. 1554; Sweet, Brit. Fl. Gard. n. s. iii. t. 219; Benth. l. c. 301; Hemsl. l. c. 552; Gray, Syn. Fl. N. A. ii. 369; Briq. l. c. *S. reptans*, Jacq. Hort. Schoen. iii. 38, t. 319. *S. virgata*, Ort. Dec. i. 3. — Central and Southern Mexico. ZACATECAS, near Plateado, Sept. 2, 1897 (*J. N. Rose*, no. 2745): JALISCO, Valley of Mexico, Tizapan, June 26, 1865–66 (*Bourgeau*, no. 125, in part): MICHOACAN, Tlalpujahua 1828 (*Graham*); plains near Patzcuaro, Aug. 7, 1892 (*C. G. Pringle*, no. 4163). *S. linifolia*, Mart. & Gal. l. c. 70, and Benth. l. c. 302, from MICHOACAN is probably only a form with rose-colored corolla.

Var. GLABRA, Gray, l. c. Stems and leaves glabrous. — *S. leptophylla*, Benth. Lab. 249, & in DC. l. c. 299. *S. azurea*, Torr. Bot. Mex. Bound. 131, in part. — From Texas through central and southern Mexico, of broader range than the hispid type. SAN LUIS POTOSI, in sand near the city of San Luis Potosi, 1876 (*Schaffner*, no. 672): AGUAS CALIENTES (*Hartweg*, no. 163); JALISCO, edge of swamp, Guadalajara, July, 1886 (*Edw. Palmer*, no. 226): CHIAPAS, without locality, 1864–70 (*Ghiesbreght*, no. 751); valley of Jiquipilas, alt. 650–1,100 m., Aug. 16, 1895 (*E. W. Nelson*, no. 2922).

= = Glandular-hairy.

30. **S. heterotricha.** Stems erect from a rather woody base, 2.5 to 4.5 dm. high, puberulent, and, especially above, bearing slender jointed glandular hairs: leaves linear-attenuate, strongly 1–3-nerved, 3 to 8 cm. long, puberulent or glabrate or rarely with some slender glandular hairs: raceme 2 cm. or less in length; verticels all remote, the lower 3 to 4 cm. apart, 3–9-flowered: bracts lanceolate to ovate-lanceolate, glandular-

ciliate, mostly shorter than the calyx: pedicels 2 to 4 mm. long: calyx tubular-campanulate, in anthesis 8 to 10 mm. long, glandular-ciliate on the strong nerves; lobes about 3 mm. long; the upper lip broadly ovate, bluntish, entire; lower lip with 2 slightly narrower and more pointed lobes: corolla blue or violet as in *S. angustifolia,* but the galea more pubescent: style bearded. — *S. angustifolia,* Gray in Wats. Proc. Am. Acad. xx. 445, in part, not Cav. — JALISCO, in bottoms, Rio Blanco, June, 1866 (*Edw. Palmer,* no. 53); plains near Guadalajara, July 1, 1889 (*C. G. Pringle,* no. 2913).

Var. **multinervia.** Leaves lance-linear to oblanceolate, mostly with 5 parallel nerves. — TEPIC, foothills between Acaponeta and Pedro Paulo, Aug. 2, 1897 (*J. N. Rose,* no. 1934).

++ ++ **Raceme long-pedunculate: leaves confined to the lower half of the plant.**

= **Upper lobe of the calyx tridentate.**

a. **Calyx-tube pilose-hispid, not glandular: attenuate bracts glabrous or glabrate.**

31. S. COMOSA, Peyr. Stem 2 to 6 dm. high, glabrous or glandular-pilose: leaves membranaceous, linear or lanceolate, the upper half crenate-serrate, generally pubescent beneath on the veins. — Linnaea, xxx. 32; Hemsl. l. c. 555. *S. glechomaefolia,* Wats. Proc. Am. Acad. xviii. 137, in part, not HBK. — Central and southeastern Mexico. Without locality (*Coulter,* no. 1115): SAN LUIS POTOSI, without locality, 1878 (*Parry & Palmer,* no. 761): MEXICO, Santa Fé, July 6, 1865–66 (*Bourgeau,* n. 396): VERA CRUZ, Mt. Orizaba, alt. 2,460 to 2,770 m., Aug., 1891 (*Seaton,* nos. 259, 323). Originally described from Toluca, MEXICO.

Var. **hypoglauca.** Similar, glabrous: leaves slightly petioled, very glabrous, glaucous beneath, entire or serrulate at tip. — *S. hypoglauca,* Briq. Ann. Conserv. Jard. Bot. Genève, ii. 136. — MICHOACAN, mountains about Patzcuaro, July 30, 1892 (*C. G. Pringle,* no. 4155). A glabrous and glaucous extreme, not separable otherwise from *S. comosa.*

b. **Calyx and attenuate bracts glandular-hispid.**

1. **Leaves linear, revolute, with one conspicuous broad nerve.**

32. **S. unicostata.** Slender, 2 to 4 dm. high: stem sparingly glandular-hispid: leaves 3 to 6 cm. long, 2 mm. or less wide, glabrous: peduncles 0.5 to 1 dm. long; raceme 1 to 1.5 dm. long, the lower verticels 0.5 dm. apart, the upper approximate; verticels 3–6-flowered: bracts short, ovate, subulate-tipped: calyx in anthesis 5 mm. long, the tube equalling the lance-subulate lobes: corolla 1.3 cm. long, puberulent. —

S. angustifolia, var. *glabra*, Wats. Proc. Am. Acad. xviii. 138, in part, not Gray. — SAN LUIS POTOSI, without locality, alt. 1,840 to 2,460 m., 1878 (*Parry & Palmer*, no. 760).

2. Leaves oblanceolate, pinnately nerved.

33. **S. firma.** Stems decumbent at base, glabrous below, glandular-pubescent in the inflorescence, 4 to 5 dm. high: leaves 4 to 8 cm. long, 0.5 to 2 cm. broad, acute or blunt at tip, cuneate at base, crenulate-serrate, thick and firm, glabrous, above sublucid: peduncles elongated, 1–2-bracteate; racemes becoming 3 dm. long; verticels all distinct, 3–6-flowered, the lowermost 5 to 8 cm. apart: bracts short, broad-ovate, subulate-tipped: pedicels short: calyx campanulate, in anthesis 5 to 6 mm., becoming 1 cm. long; tube twice exceeding the lobes; upper lip broad-ovate, the teeth subulate; lobes of the lower lip with long subulate tips: corolla 1.5 cm. long, the tube slightly exserted, the dark blue lower lip with a pale spot in its centre and twice exceeding the puberulent blunt galea: style bearded. — *S. glechomaefolia*, Wats. l. c. not HBK. — JALISCO, on hill-sides, Rio Blanco, June, 1886 (*Edw. Palmer*, no. 61).

= = Upper lip of calyx entire.

a. Glabrous: leaves oblong-lanceolate: bracts round, obtuse or short-mucronate.

34. S. LAEVIS, Benth. Lab. 251, & in DC. l. c. 303; Hemsl. l. c. 559; Briq. l. c. & in Engl. & Prantl, l. c. — Not seen. Described from Mexico and from near Tlalpujahua, MICHOACAN.

b. Pubescent: leaves elliptic-oblanceolate or narrowly obovate: bracts ovate, long-attenuate.

35. **S. sinaloensis.** Stems slender, 2 to 2.5 dm. high, slightly branched, below short- hirsute, above and in the inflorescence densely pubescent with long straight fine viscid hairs: leaves acutish, the upper half appressed-serrate, the lower half subentire, subcuneate to a sessile base or obscurely short-petioled; those of the main stem 3 to 4 pairs, the uppermost largest, 3.5 to 6 cm. long, 1.25 to 2 cm. broad, above appressed short-setulose or glabrate, beneath pale, minutely setulose on the nerves: peduncle 6 to 9 cm. long, about equalling the leafy lower portion of the plant; raceme becoming 1 dm. or so long; verticels 3–6-flowered, the lower 4 cm. apart, the upper rather approximate: bracts pilose-hispid, colored, soon deciduous: calyx densely pilose-hispid with fine viscid hairs, in anthesis 5 to 7 mm. long; the tube twice as long as the broad abruptly subulate-tipped lobes: corolla 1.5 cm. long, the tube slightly exserted, the dark blue lip with a pale spot in its centre twice exceeding the puberu-

lent blunt oblong galea: style bearded. — SINALOA, foothills of the Sierra Madre near Colomas, July 14, 1897 (*J. N. Rose*, no. 1727).

+ + Leaves nearly all with definite petioles. (*S. comosa* and *S. sinaloensis* may be looked for here.)

++ Annuals, more or less bushy-branched: racemes elongated, at least the lower verticels remote.

= Leaves linear-lanceolate to oblong-linear, obscurely serrate: bracts lanceolate.

36. S. LANCEOLATA, Brouss. App. Elench. Pl. Hort. Monsp. (1805) 15; Willd. Enum. Hort. Berol. i. 37; Jacq.f. Eclog. i. 22, t. 13; Benth. l. c. 299; Gray, l. c. 369; Hemsl. l. c.; Briq. l. c. *S. reflexa*, Horn. Hort. Hafn. (1807), i. 34. *S. lanceifolia*, Poir. Suppl. v. 49. *S. aspidophylla*, R. & S. Syst. Mant. i. 206. *S. trichostemoides*, Pursh, Fl. i. 19. *S. aegyptiaca*, Sessé & Moc. l. c. 6, not L. — Florida and S. W. United States to Central Mexico. Without locality, 1848–49 (*Gregg*, no. 541): CHIHUAHUA, low ground near Chihuahua, Oct. 1852 (*Geo. Thurber*, no. 821); plains near Chihuahua, Sept. 11, 1885 (*C. G. Pringle*, no. 654); damp places near Pilares, Sept. 23, 1891 (*C. V. Hartman*, no. 744): COAHUILA, abundant in abandoned fields and bottom-lands, Saltillo, Sept., 1898 (*Edw. Palmer*, no. 336): DURANGO, abundant in rich bottom-lands, near Durango, July, 1896 (*Edw. Palmer*, no. 327); along arroyos, Santiago Papasquiaro, Aug., 1896 (*Edw. Palmer*, no. 446); between Cerro Prieto and La Providencia, Sept. 11, 1898 (*E. W. Nelson*, 4969): SAN LUIS POTOSI, damp places about the city, 1876 (*Schaffner*, no. 673); alt. 1,840 to 2,460 m., 1878 (*Parry & Palmer*, no. 744): GUANAJUATO, Presa de la olla, 1893 (*A. Dugès*): QUERETARO, Nov. 19, 1827 (*Berlandier*, no. 1279).

= = Leaves lanceolate or oblong-lanceolate, coarsely subincised-dentate: bracts broadly ovate.

37. S. SUBINCISA, Benth. Pl. Hartw. 20, & in DC. l. c. 303; Gray, l. c.; Hemsl. l. c. 565; Briq. l. c. — Texas to Central Mexico. CHIHUAHUA, Pilares, Sept. 18, 1891 (*C. V. Hartman*, no. 776): DURANGO, rich low ground near Durango, July, 1896 (*Edw. Palmer*, no. 305): AGUAS CALIENTES, in fields near the city (*Hartweg*, no. 160). Originally described from Hartweg's plant.

= = = Leaves ovate or narrowly rhombic-ovate, crenate-serrate: bracts narrowly ovate with long attenuate barbulate tips.

38. **S. Chia.** Similar to the two preceding: about 6 dm. high, with long internodes (the lower 5 to 7 cm. long): stem strongly quadrangular, puberulent with appressed white hairs, densely white-pilose at the nodes:

leaves bluntish at tip, cuneate at base to a long slender petiole, coarsely crenate-serrate, especially above the subentire base; margin and petiole densely short-pilose; upper face dark green, puberulent or glabrate; lower face paler, minutely pubescent: racemes very short-pedunculate, 0.5 to 2 dm. long; verticels 3–6-flowered, the lower 1.5 cm. apart, the upper approximate: pedicels 3 mm. long, minutely white-pilose: calyx ciliate on the strong nerves, narrowly campanulate, in anthesis 8 mm. long; the tube twice exceeding the ovate acuminate lobes; upper lip entire: corolla 1.3 to 1.5 cm. long, the white tube somewhat exserted; lips blue, the lower pubescent beneath, twice as long as the pubescent upper one: style glabrous. — Coahuila, damp bottom-lands, Saltillo, Sept., 1898 (*Edw. Palmer*, no. 334). This as well as three other species, *S. lanceolata*, *S. tiliaefolia*, and *S. hispanica*, are called *chia* by the Mexicans, and a cooling beverage known likewise by that name is prepared from the seed. (See Rose, Contr. U. S. Nat. Herb. v. 225.)

++ ++ Perennials, mostly decumbent at least at base.

= The lower verticels becoming remote.

a. Corolla white or pale: stem strongly decumbent or subrepent: leaves ovate-elliptic to oblong, glabrate: peduncle 0.5 to 1.5 dm. long.

39. S. assurgens, HBK. Nov. Gen. & Spec. ii. 293; Benth. l. c. 304; Hemsl. l. c. 553; Briq. l. c. — Michoacan, grassy hills near Patzcuaro, July 18, 1892 (*C. G. Pringle*, no. 4150); Oct. 20, 1898 (*E. W. D. Holway*, no. 3184); originally collected near the same town, alt. 2,100 m., by Humboldt & Bonpland. According to Kunth the color of the corollae is "pallide violacea? (carnea ex Bonpl.)," but neither of the recently collected specimens shows any violet tinge.

b. Corolla blue or violet.

1. Pilose-hirsute: internodes short: leaves oblong to rhombic-ovate: calyx hispid below, in anthesis 5 to 7 mm. long; tube equalling the lobes; upper lip tridentate or entire.

40. S. prunelloides, HBK. l. c. 289; Benth. l. c. 305; Hemsley, l. c. 563; Briq. l. c. *S. glechomaefolia*, Wats. Proc. Am. Acad. xviii. 137, not HBK. *S. tricandra*, Briq. Ann. Conserv. Jard. Bot. Genève, ii. 133. — Coahuila to Oaxaca. Coahuila, mountains 64 km. south of Saltillo, July, 1880 (*Edw. Palmer*, no. 1098); limestone hills, Carneros Pass, Sept. 27, 1890 (*C. G. Pringle*, no. 3681): Nuevo Leon, Lerios, July, 1880 (*Edw. Palmer*, no. 1097): Durango, Cacaria, Aug. 5, 1898 *E. W. Nelson*, no. 4651): Mexico, without locality, 1848–49 (*Gregg*, no. 406); cool slopes, Sierra de las Cruces, Aug. 21, 1892 (*C. G. Prin*

gle, no. 4200): OAXACA, Cuilapan, alt. 1,840 m., June 27, 1895 (*L. C. Smith*, no. 778). Originally from Volcan de Jorullo, MICHOACAN. Briquet bases his species *S. trichandra* upon Pringle's no. 4200, stating in his description of the calyx that the upper lip is entire. In the specimens of this number, as represented in the Gray Herbarium, the upper lip is usually tridentate, thus placing the plant distinctly with *S. prunelloides*.

2. Puberulent: internodes longer: leaves oblong or narrowly ovate-oblong: calyx puberulent, tubular-campanulate, in anthesis 7 to 8 mm. long, the tube one half longer than the lobes; upper lip entire.

41. S. OBLONGIFOLIA, Mart. & Gal. l. c. 79; Benth. l. c.; Hemsl. l. c. 562; Briq. in Engl. & Prantl, l. c. *S. reticulata*, Mart. & Gal. l. c. 64, acc. to Benth. — Southern Mexico. CHIAPAS, without locality, July, Aug., 1864–70 (*Ghiesbreght*, nos. 61, 750); near San Cristobal, alt. 2,150 to 2,460 m., Sept. 18, 1895 (*E. W. Nelson*, no. 3191). Originally described from OAXACA.

= = Verticels congested in a long-peduncled head: stem pilose-hispid, 2 to 2.5 dm. high: leaves ovate-elliptic or ovate-oblong, obtuse: heads 1 to 1.5 cm. high.

42. S. TATEI, Briq. Ann. Conserv. Jard. Bot. Genève, ii. 135. — Mexico, without indicated locality in herb. Delessert. Not seen.

* * * Bracts deciduous: calyx cylindric, not becoming inflated, less conspicuously bilabiate: stems numerous from a woody base.

+ Bracts very early deciduous: calyx blue-tinged, conspicuously nerved, puberulent or short-pubescent.

++ Verticels, or all but the lowermost, aggregated, forming a rather dense head.

= Stems 1 m. or less high, finely canescent: leaves 2 to 8 cm. long, soft-canescent beneath: heads simple or branched, 2 to 12 cm. long: calyx, in anthesis, 5 to 7 mm. long; the tube thrice exceeding the deltoid subulate-acuminate lobes: corolla blue rose or white.

43. S. LAVENDULOIDES, HBK. Leaves lanceolate, oblanceolate, or oblong-lanceolate, acutish or blunt, crenulate. — Nov. Gen. & Spec. ii. 287; Benth. l. c. 303; Hemsl. l. c. 559; Briq. l. c. *S. Humboldtiana*, R. & S. Syst. Mant. i. 183. *S. lavendulaefolia*, Spreng. Syst. i. 58, not Vahl. *S. purpurina*, La Llave, La Nat. vii. 82. *S. stricta*, Sessé & Moc. l. c. 8. — Southern Mexico and Central America. MEXICO, Valley of Mexico (*Bourgeau*, no. 1110, *Schaffner*, no. 410): MICHOACAN, hills of Patzcuaro, Nov. 21, 1891 (*C. G. Pringle*, no. 3954): MORELOS, Cuernavaca, alt. 2,300 m., Jan. 4, 1899 (*C. C. Deam*, no. 2): OAXACA, N. W. slope of Mt. Zempoaltepec, alt. 2,460 to 3,000 m., July 10, 1894 (*E. W. Nelson*, no. 701): Cuyamecalco, alt. 2,000 m., Sept. 4, 1895 (*L. C. Smith*,

no. 601): CHIAPAS, without locality, 1864–70 (*Ghiesbreght*, nos. 738, 741, 747); near San Cristobal, alt. 2,150 to 2,460 m., Sept. 18, 1895 (*E. W. Nelson*, no. 3142): GUATEMALA, Santa Rosa, Depart. Baja Verapaz, alt. 1,530 m., April, 1887 (*H. von Tuerckheim* in exsicc. J. D. Smith, no. 1193); Santiago, Depart. Zacatepéquez, alt. 2,000 m., 1891 (*Rosalío Gómez* in exsicc. J. D. Smith, no. 823); Sacabajá, Depart. Quiché, alt. 1,230 m., March, 1892, and Castillas, Depart. Santa Rosa, alt. 1,230 m., Dec., 1892 (*Heyde & Lux* in exsicc. J. D. Smith, nos. 3128, 4395). Originally described from Patzcuaro, MICHOACAN.

Var. LATIFOLIA, Benth. Leaves elliptic-oblong, acute. — Pl. Hartw. 21, & in DC. l. c. — JALISCO, Bolaños (*Hartweg*, no. 171).

= = Similar: stems minutely retrorse-pubescent: leaves not canescent beneath.

a. Leaves oblong or narrowly ovate-elliptic, 1.5 to 3 cm. long, thickish, rugose, green, sometimes a little pubescent on the nerves beneath, obscurely crenate or entire: lower verticels a little remote: calyx 5 to 6 mm. long the upper lip very short, the lower with 2 ovate lobes 1 mm. long.

44. S. GUADALAJARENSIS, Briq. Ann. Conserv. Jard. Bot. Genève ii. 132. *S. helianthemifolia*, var., Gray in Wats. Proc. Am. Acad. xxii. 445, not *S. helianthemifolia*, Benth. — JALISCO, among rocks, Rio Blanco, Sept., 1886 (*Edw. Palmer*, no. 556); dry rocky hills near Guadalajara, Nov. 1, 1893 (*C. G. Pringle*, no. 4624).

b. Leaves lanceolate or oblong-linear, bluntish, dull, minutely puberulent or glabrate: deltoid acuminate calyx-lobes subequal.

1. Stems numerous, assurgent, 2 to 2.5 dm. high, leafy chiefly near the base: leaves entire, glaucous: calyx white-puberulent, in anthesis 6 mm. long.

45. **S. Teresae.** Leaves short-petioled, 2 to 2.5 cm. long, 0.25 to 0.5 cm. broad: peduncles 1 to 1.5 dm. long; raceme rather loosely flowered; the lower verticels 1 cm. apart, 2–6-flowered: bracts ovate-lanceolate, acuminate: calyx dark blue: corolla 1.3 cm. long, the galea densely pubescent. — TEPIC, near Santa Teresa, top of Sierra Madre, Aug. 13, 1897 (*J. N. Rose*, no. 2233).

2. Stems few, erect, 6 to 8 dm. high: leaves remote, serrate, not glaucous: calyx minutely pubescent, not whitened, in anthesis 4 to 5 mm. long.

46. **S. muscarioides.** Stems simple or sparingly branched; internodes 1 dm. or less long; leaves short-petioled, 5 to 6 cm. long, 0.75 to 1.5 cm. wide: peduncles 2 dm. or less long: bracts minute, caducous: lower verticels 2 or 3 cm. apart, the others crowded, 8–20-flowered: pedicels spreading and drooping: calyx dark blue and green: corolla 1.2 cm. long; the lower lip much exceeding the pubescent galea: style slightly exserted, bearded. — Northwestern Mexico. CHIHUAHUA, base

of Mt. Mohinora, 13 km. from Guadalupe y Calvo, alt. 2,150 to 2,310 m., Aug., 1898 (*E. W. Nelson*, no. 4850). Inflorescence, as also that of related species, suggesting *Muscari botryodes*.

++ ++ Verticels mostly remote, forming an elongate loose raceme.

= Stem 5 to 6 dm. high: leaves oblong, blunt or acutish: racemes 2.5 dm. long or less; verticels 6–20-flowered, lower 4 to 5 cm. apart, upper approximate: calyces reflexed: corolla 1 cm. long, the tube included or short-exserted.

47. S. HELIANTHEMIFOLIA, Benth. Lab. 254, & in DC. l. c. 304; Hemsl. l. c. 557; Briq. in Engl. & Prantl, l. c. — South-central Mexico. SAN LUIS POTOSI, alt. 1,840 m., 1878 (*Parry & Palmer*, no. 729): HIDALGO, Sierra de Pachuca, alt. 3,000 m., Sept. 14, 1899 (*C. G. Pringle*, no. 8222): MICHOACAN, near Tlalpujahua (*Graham*). Described from Graham's material from Tlalpujahua and from San Martin, PUEBLA.

= = Similar: leaves oblong-lanceolate, acute, serrate: verticels subequally remote: calyces less reflexed: corolla-tube equalling the calyx.

48. S. REMOTA, Benth. l. c.; Hemsl. l. c. 564; Briq. l. c. Described from Mexico without definite locality.

+ + Bracts hardly persistent, lower verticels becoming slightly remote: nerves of calyx hidden by the long appressed silky pubescence.

49. **S. cryptodonta.** Resembling *S. lavenduloides*: stems canescent: leaves narrow-oblong, blunt, crenate-serrate, 2 to 5 cm. long, 0.5 to 1.5 cm. wide, rugose, green and appressed-setulose above, white-tomentose beneath, short-petioled: raceme 2 to 5 cm. long; bracts ovate-lanceolate, acuminate, ascending: calyx blue, in anthesis 5 mm. long, the short teeth obscured by the dense silky hairs: corolla 1 cm. long, the tube barely exserted; galea pilose, half as long as the lip. — DURANGO, Aug. 16, 1897 (*J. N. Rose*, no. 2338).

+ + + Bracts persistent through anthesis, their slender tips conspicuous: nerves of calyx somewhat hidden by long hairs: heads very dense.

= Leaves lanceolate, slightly canescent: the long-peduncled heads 3 to 5 cm. in length: bracts ascending: calyx white-villous.

50. S. STACHYOIDES, HBK. l. c. t. 138; Benth. l. c. 303; Hemsl. l. c. 565; Briq. l. c. — Southern Mexico. OAXACA, 29 km. S. W. of the city of Oaxaca, alt. 2,300 to 2,920 m., Sept., 1894 (*E. W. Nelson*, no. 1387). Originally from Los Joares and Santa Rosa.

= = Leaves oblong, glabrous or slightly puberulent: heads 2 to 13 cm. long: bracts more spreading: calyx pilose-hirsute.

51. S. ELONGATA, HBK. l. c. t. 139; Benth. l. c.; Hemsl. l. c. 556. *S. Betonica*, R. & S. l. c. 188. *S. simplex*, Spreng. Syst. i. 58. — South-

central Mexico. MEXICO, Valley of Mexico, Sept. 7, 1865–66 (*Bourgeau*, no. 859); wooded cañons, Sierra de las Cruces, Oct. 2, 1892, and Serrania de Ajusco, alt. 3,075 m., Sept. 11, 1897 (*C. G. Pringle*, nos. 4278, 7457). Originally from the region of Ario, MICHOACAN.

B. Acaulae. Similar to *Angustifoliae* but tending to be acaulescent or subacaulescent, the obovate canescent basal leaves forming a rosette: peduncle 0.5 to 2.5 dm. high; raceme as long; the verticels remote.

52. S. NANA, HBK. l. c. 289; Benth. in DC. l. c. 304; Hemsl. l. c. 561; Briq. l. c. *S. prunelloides*, Benth. Pl. Hartw. 90, 351, not HBK. *S. rhombifolia*, Sessé & Moc. l. c. 8. — Northern Mexico to Central America. DURANGO, El Salto, July 12, 1898 (*E. W. Nelson*, no. 4566): ZACATECAS, near San Juan Capistrano, Aug. 18, 1897 (*J. N. Rose*, no. 3534): SAN LUIS POTOSI, rare in the mountains, San Rafael, 1876 (*Schaffner*, no. 680); alt. 1,840 m. (*Parry & Palmer*, no. 745, 746): GUANAJUATO, 1893 (*A. Dugès*, no. 228 B): OAXACA, Boca de Leon, Telixtlahuaca, June 27, 1895 (*L. C. Smith*, no. 414). Originally from GUANAJUATO.

C. Vulgares, Benth. Branching or sometimes simple herbs, rarely half-shrubs: leaves petioled, ovate, rarely oblong, membranaceous, rounded round-cuneate or subcordate at base. (*S. prunelloides* and *S. Martensii* may be looked for here.)

* Annuals.

+ Coarse more or less canescent plant with long-petioled pale-green leaves and peduncled spiciform heads with persistent foliaceous broad bracts.

53. S. HISPANICA, L. Spec. 25; Edw. Bot. Reg. v. t. 359; Benth. in DC. l. c. 308; Hemsl. l. c. 558; Briq. in Engl. & Prantl, l. c. 279. *S. tetragona*, Moench, Meth. 373. *S. prismatica*, Cav. fide Hemsl. l. c. *S. neo-hispanica*, Briq. Ann. Conserv. Jard. Bot. Genève, ii. 137. — From western Texas and Coahuila to northern South America and the West Indies. Introduced into southern Europe, whence the specific name. COAHUILA, Carneros Pass, Sept. 27, 1890 (*C. G. Pringle*, no. 3683): DURANGO, sides of arroyos, Santiago Papasquiaro, Aug., 1896 (*Edw. Palmer*, no. 967); bottom-lands, Durango, Oct., 1896 (*Edw. Palmer*, no. 757): SAN LUIS POTOSI, sand near the city, 1876 (*Schaffner*, nos. 675, 1053): GUANAJUATO, 1895 (*A. Dugès*): JALISCO, Rio Blanco, Oct., 1886 (*Edw. Palmer*, no. 659): VERA CRUZ, Orizaba (*Botteri*, no. 534): MEXICO, Santa Fé, Oct. 15, 1865–66 (*Bourgeau*, no. 1109): OAXACA, near Reyes, alt. 1,800 to 2,600 m., Oct. 20, 1894 (*E. W. Nelson*, no. 1782); Jayacatlan, alt. 1,350 m., Nov. 4, 1894

(*L. C. Smith*, no. 268): GUATEMALA, Buena Vista, Depart. Santa Rosa, alt. 1,700 m., Dec., 1892 (*Heyde & Lux* in exsicc. J. D. Smith, no. 4401). Frequently cultivated in Mexico as "Chia-blanco" — see note under *S. Chia* above.

+ + **Delicate, not canescent: leaves short-petioled: bracts small, deciduous.**

54. **S. flaccida.** Slender, 2 to 3 dm. high, simple or branching from the base, puberulent below, more or less glandular-pilose above: leaves very thin and flaccid, glabrous and lucid or minutely hispidulous on the nerves beneath, from rhombic-ovate to oblong-ovate, short-acuminate, coarsely appressed-serrate, cuneate and entire at base, the uppermost largest, 4 to 6 cm. long, 2 to 3.5 cm. broad; petioles slender, puberulent, 0.5 to 1.5 cm. long: peduncle 4 to 5 cm. long; raceme short, 2 to 3 cm. long, of 2 or 3 remote 3–6-flowered verticels: bracts lanceolate: pedicels 3 mm. long: calyx minutely glandular-hispidulous, narrow-campanulate, in anthesis nearly 1 cm. long; the upper lip bluish, entire, ovate, bluntly mucronate; the lower lip paler, with 2 lance-attenuate lobes: corolla 2 to 2.5 cm. long, the white tube one half longer than the calyx, hardly ventricose; galea blue, puberulent, one half as long as the broad white lip. — Southern Mexico and adjacent Central America. CHIAPAS, between Tumbala and El Salto, alt. 460 to 1,380 m., Oct. 29, 1895 (*E. W. Nelson*, no. 3374): GUATEMALA, in woods, Rubeleruz, Depart. Alta Verapaz, alt. 770 m., Oct., 1885 (*H. von Tuerckheim* in exsicc. J. D. Smith, no. 780).

* * **Perennials.**

+ **Erect or suberect, branching mostly above the base, leafy nearly or quite to the inflorescence.**

++ **Leaves rounded rounded-truncate or subcordate at base, not tapering to the distinct petioles.**

= **Calyx in anthesis about 8 mm. long.**

a. **Racemes terminal and from the upper axils, panicled, and often branching: leaves pale green, glaucous beneath: calyx minutely puberulent, with very short broad-deltoid teeth.**

1. **Racemes 2 to 7 cm. long, compactly flowered: pedicels 1 mm. long.**

55. S. BREVICALYX, Benth. in DC. l. c. 309; Hemsl. l. c. 553. — Southern Mexico. GUERRERO, between Ayuainapa and Petatlan, alt. 1,530 to 2,150 m. Dec. 14, 1894, and at top of Sierra Madre near Chilpancingo, alt. 2,770 to 3,140 m., Dec. 24, 1894 (*E. W. Nelson*, nos. 2146, 2220): OAXACA, mountains near Tlapancingo, alt. 1,840 to 2,460 m., Dec. 7, 1894 (*E. W. Nelson*, no. 2064). Originally from OAXACA.

2. Racemes longer, slender: pedicels 2 to 3 mm. long, equalling the calyx.

56. S. filipes, Benth. l. c.; Hemsl. l. c. 556. *S. polystachya*, var., Benth. Pl. Hartw. 50, not *S. polystachya*, Ort. Described from Regla. Not seen.

b. Racemes short, simple, solitary, or paniculate, with some remote lower verticels in the axils of the upper foliar leaves: calyx hispidulous, with short deltoid-subulate teeth.

57. **S. menthiformis**. Tall herb, 6 to 8 dm. high: stems strongly angular and furrowed, cinereous-puberulent, freely branching: leaves ovate or orbicular-ovate, acuminate, round-cordate at base, crenulate-serrate, 1.5 to 5 cm. long, 1 to 3.5 cm. broad, dark green and glabrate above, pale and minutely puberulent or glabrate beneath, on slender cinereous-puberulent petioles 1 to 2 cm. long; raceme, excluding the remote axillary verticels, 2 to 5 cm. long; the crowded verticels 6–20-flowered: pedicels barely 1 mm. long: corolla blue, pilose, 1.2 cm. long; the tube twice exceeding the calyx; the lip hardly equalling the galea: style glabrous or slightly bearded. — *S. polystachya*, Donnell Smith, Enum. Pl. Guat. iv. 126, not Ort. *S. purpurea*, Donnell Smith, l. c. in part, not Cav. — Costa Rica, Cartago, alt. 1,300 m., Oct., 1887 (*Juan J. Cooper* in exsicc. J. D. Smith, no. 5902); San Francisco de Guadalupe, alt. 1,200 m., Jan., 1894 (*A. Tonduz*, no. 1781); Rio Turrialba, Prov. Cartago, alt. 500 m., March, 1894 (*J. D. Smith*, no. 4919). Habitally resembling forms of *Mentha aquatica*.

c. Racemes simple, with no axillary lower verticels.

1. Raceme spiciform, densely flowered, 4 to 10 cm. long: leaves broad-ovate, 1 dm. long, 6 dm. wide, on long petioles: corolla white.

58. S. Cataria, Briq. Ann. Conserv. Jard. Bot. Genève, ii. 142. Described from Costa Rica. No specimen seen.

2. Raceme elongate, loosely-flowered, at least the lower verticels remote.

○ Leaves broad-ovate, glabrous, coarsely and irregularly serrate: pedicels 2 to 4 mm. long.

59. S. brachyodonta, Briq. l. c. 149. *S. albiflora*, var. *caerulescens*, Gray in Wats. Proc. Am. Acad. xxii. 445, in part. — Jalisco, on sides of cañons, Rio Blanco, Sept., 1886 (*Edw. Palmer*, no. 598); hillsides near Guadalajara, Sept. 27, 1889 (*C. G. Pringle*, no. 2463). Placed by Briquet under the group *Cordifoliae*, Benth., but the leaves are rounded-truncate at base, not cordate, and in habit as well the plant much more resembles members of the *Vulgares*.

○ ○ Leaves narrow-ovate, lanate beneath in the axils of the nerves, finely and regularly serrate: pedicels 1 mm. long.

60. **S. Ghiesbreghtii.** Tall, 1 m. (?) or less high: stems puberulent, with long ascending branches: leaves long-acuminate, rounded at base, 3 to 6 cm. long, 1 to 3 cm. wide, puberulent above, pilose or glabrate beneath, except for the often densely lanate mid-nerve, on petioles 1 cm. or less in length: racemes slender, flexuous, 1 to 2.5 dm. long; verticels 10–20-flowered, the lower 1.5 cm. apart: bracts small, ovate-attenuate, caducous: calyx hispid, with short-deltoid ciliate subulate-tipped teeth: corolla pale blue, pilose, 1.2 cm. long; the ventricose tube twice exceeding the calyx; galea and lip subequal: style bearded. — *S. polystachya*, Hemsl. l. c. 563, in part, not Ort. — CHIAPAS, among the mountains, July, 1864–70 (*Ghiesbreght*, nos. 129, 743).

= = Calyx in anthesis about 5 mm. long.

a. Lower surfaces of firm leaves the pedicels and the calyces permanently canescent with fine stellate pubescence.

61. S. PALMERI, Gray, Proc. Am. Acad. xxi. 408. — CHIHUAHUA, hillsides at the Frailes, on the mountains above Batopilas, 1885 (*Edw. Palmer*, no. 259).

b. Lower surfaces of leaves the pedicels and the calyces canescent with appressed short hairs: racemes very elongated, the verticels subequally remote: broad lip of corolla much exceeding the galea.

62. S. LEPTOSTACHYS, Benth. Lab. 258, & in DC. l. c. 308; Hemsl. l. c. 560; Briq. in Engl. & Prantl, l. c. — South central Mexico. JALISCO, near Plateado, Aug. 31, 1897 (*J. N. Rose*, no. 2682): MORELOS, hills near Cuernavaca, Nov. 10, 1895 (*C. G. Pringle*, no. 7078).

c. Lower surfaces of leaves canescent-tomentose, glabrate or glabrous: calyx villous or hirsute: galea and lip of corolla subequal.

63. S. POLYSTACHYA, Ort. Leaves broad-ovate, tomentose beneath: racemes panicled: calyx canescent, villous. — Dec. 55; Cav. Ic. i. 17, t. 27; HBK. l. c. 296; Benth. l. c.; Hemsl. l. c. 563; Briq. l. c. *S. linearifolia*, Lag. Nov. Gen. & Spec. 2. *S. Durandiana* (as subspecies), Briq. Bull. Soc. Bot. Belg. xxx. 238, & Ann. Conserv. Jard. Bot. Genève, ii. 138. — An extremely variable species, the typical form seen only from MICHOACAN, Tlalpujahua (*Graham*).

Var. CAESIA, Briq. Leaves narrow-ovate to ovate-lanceolate, glaucous, glabrous or minutely pubescent, not tomentose, beneath: inflorescence as in the type but racemes more elongated, the lower verticels often remote:

calyx generally with shorter pubescence. — Bull. Soc. Bot. Belg. xxx. 236 & Ann. Conserv. Jard. Bot. Genève, l. c. *S. caesia*, Willd. Enum. i. 40; HBK. l. c. 295. — Central Mexico to Central America. HIDALGO, Guadalupe, Valley of Mexico, Aug., 1865–66 (*Bourgeau*, nos. 721, 854), Aug. 17, 1865 (*Bilimek*, no. 316): MEXICO, Takubaya, Aug. 28, 1865 (*Bilimek*, no. 315): OAXACA, near Puebla, alt. 2,150 m., Nov. 9, 1895 (L. C. Smith, no. 908).

Var. **philippensis.** Leaves as in the species: racemes simple, elongated, 1 to 2 dm. long: calyx short villous. — OAXACA, Sierra de San Felipe, alt. 2,300 m., Sept. 1, 1894 (*E. W. Nelson*, no. 1175), Oct. 5, 1894 (*C. G. Pringle*, no. 4953).

Var. **seorsa.** Similar to the last: leaves glabrate beneath: racemes simple, elongated; verticels many-flowered, the lower 2 to 3 cm. apart. — MEXICO, Valley of Mexico, Sept. 19, 1889 (*C. G. Pringle*, no. 2818).

Var. **albicans.** Leaves ovate, thinner than in the other forms, slightly canescent above, very white-tomentose beneath: racemes simple, 1 to 1.5 dm. long: calyx densely white-villous. — *S. purpurea*, var. *pubens*, Donnell Smith, l. c. iii. 67, not Gray. — GUATEMALA, Santa Rosa, Depart. Santa Rosa, alt. 920 m., Nov., 1892 (*Heyde & Lux* in exsicc. J. D. Smith no. 4394). An extremely canescent plant.

Var. POTOSINA, Briq. l. c. Leaves ovate-lanceolate or lanceolate, long-acuminate, pubescent as in the species: racemes simple, 1 dm. or less long: calyx hirsute. — SAN LUIS POTOSI, San José Pass, July 23, 1890 (*C. G. Pringle*, no. 3224).

d. Leaves pilose-hispid or glabrate beneath: stems and calyces pubescent with slender spreading glandular hairs.

64. **S. aequidistans.** Erect or ascending: stems 1.5 to 4 dm. high, glandular-hirsute: leaves rather remote, the lower small, the upper much larger, oblong-ovate to broadly deltoid-ovate, obtuse, the uppermost 3 to 4.5 cm. long, crenate-serrate, more or less setulose above: racemes slender, elongated, 0.5 to 2 dm. long; the verticels 2–6-flowered, all remote, the lower equidistant, 2 to 3 cm. apart: pedicels filiform, 2 to 4 mm. long: calyx campanulate, strongly bilabiate, the tube twice or thrice as long as the ovate lips; upper lip entire, lower short-cleft: corolla 1.3 cm. long, the pilose or glabrate tube ventricose, nearly twice exceeding the calyx; lip a little exceeding the pilose galea: style bearded. — SINALOA, between Rosario and Colomas, July 12, 1897 (*J. N. Rose*, no. 1609).

= = = Calyx in anthesis 6 to 8 mm. long.

a. Leaves broad-ovate, crenate-serrate, obtuse: bracts large, broad-ovate: upper lip of purple glandular-hairy calyx tridentate: corolla dark-blue, with the calyx, bracts, &c., red-dotted.

65. S. TRICUSPIDATA, Mart. & Gal. l. c. 78; Benth. l. c. 311; Hemsl. l. c. 566. — OAXACA, Sierra de San Felipe, alt. 3,080 m., Aug. 28, 1894 (*C. G. Pringle*, no. 4845). Originally collected by Galeotti in the same mountains.

b. Leaves incised-serrate, acuminate: bracts minute, lance-subulate: calyx blue and green, minutely hispidulous, upper lip entire: corolla paler blue without red dots.

66. S. PRASIIFOLIA, Benth. Bot. Sulph. 151, & in DC. l. c. 310; Hemsl. l. c. 563. *S. aliena*, Greene, Pittonia, i. 157. — TEPIC, Maria Madre Island, April, 1877 (*W. T. Fisher*), May, 1897 (*E. W. Nelson*, no. 4247). Originally described from Tepic.

++ ++ Five species are not identified with recent material.

From the descriptions alone it is impossible to make out their exact relationships, or whether they are all distinct from the species here defined. These five plants are: — S. GRACILIS, Benth. Lab. 258, & in DC. l. c. 307, described from "New Spain"; S. PROTRACTA, Benth. in DC. l. c. 309, described from OAXACA; S. MEMBRANACEA, Benth. Lab. 259, & in DC. l. c. 310, described from "Mexico"; S. GLABRA, Mart. & Gal. l. c. 68, Benth. l. c., described from OAXACA; S. HERBACEA, Benth. Lab. 720, & in DC. l. c. 311, described from Tehuantepec, OAXACA.

++ ++ ++ Leaves cuneate at base, or at least attenuate to the petioles.

= Leaves white-villous or pilose beneath.

a. Herbaceous.

1. Raceme dense, 4 to 7 cm. long: leaves densely villous beneath.

○ Leaves thick, crenulate-serrate.

67. S. XALAPENSIS, Benth. l. c. 308; Hemsl. l. c. 566; Briq. in Engl. & Prantl, l. c. *S. polystachya*, Mart. & Gal. l. c. 77, not Ort. — Southern Mexico. VERA CRUZ, Jalapa, alt. 1,230 to 1,380 m., Jan. 16, 1894 (*C. L. Smith*, nos. 1749, 1756); near Motzorongo and Omealca, Feb. 22, 1894 (*E. W. Nelson*, nos. 182, 177).

○ ○ Leaves thin, sharply serrate.

68. S. LONGISPICATA, Mart. & Gal. l. c. 73; Benth. l. c. 307; Hemsl. l. c. 560; Briq. l. c. — Southwestern Mexico. GUERRERO, between

Copala and Juchitango, alt. 60 to 185 m., Feb. 9, 1895 (*E. W. Nelson*, no. 2300). Originally collected by Galeotti in MICHOACAN.

2. Racemes looser, elongated, the terminal one 1 to 3 dm. long: leaves less densely villous.

○ Calyx in anthesis 4 to 5 mm. long: corolla 1 cm. long.

69. S. CORDOBENSIS, Briq. Ann. Conserv. Jard. Bot. Genève, ii. 140. — Vera Cruz, Valley of Cordova, Aug. 24, 1866, and region of Orizaba, Aug. 12, 1866 (*Bourgeau*, nos. 1591, 2857); Cordova, alt. 790 m., Aug. 20, 1891 (*Seaton*, no. 431): PUEBLA, near Metlaltoyuca, alt. 250 m., Feb. 27, 1898 (*E. A. Goldman*, no. 72).

○ ○ Calyx in anthesis 8 to 9 mm. long: corolla 2 cm. long.

70. **S. monclovensis.** Stems sparingly pilose or glabrate: leaves ovate, acuminate, coarsely crenate-serrate, the primary ones 7 to 8 cm. long, unequally cuneate or rounded-cuneate at base, dark green and minutely puberulent above, canescent beneath, on petioles 3 to 4 cm. long: peduncles 1 dm. or less long: verticels 4–8-flowered, the lowest 1.5 to 3 cm. apart: bracts narrow-ovate, long-acuminate, the lowest 1.5 cm. long, sometimes leaf-like and slightly toothed: calyx minutely appressed-pubescent; the tube thrice exceeding the broad-ovate ciliate mucronate-short-acuminate lobes: corolla blue, sparingly pilose; the tube one half longer than the calyx; the lip twice exceeding the galea: style bearded. — COAHUILA, Caracol Mts., 33.8 km. southeast of Monclova, Aug., 1880 (*Edw. Palmer*, no. 1096).

b. Shrubby at base: leaves thinly villous.

1. Stem erect, pubescent: leaves crenate-serrate: calyx-lobes broad ovate: galea of corolla glandular-pilose.

71. S. WARSZEWICZIANA, Regel, Flora, xxxii. 184; Walp. Ann. iii. 257; Hemsl. l. c. 566. — Described from GUATEMALA. No specimen seen.

2. Stem ascending, branches sordid-villous: leaves sharply serrate: lower calyx-lobes lance-ovate, long-attenuate: galea villous not glandular.

72. S. SANCTAE-LUCIAE, Seem. Bot. Herald, 327; Hemsl. l. c. 565. — Western Mexico. TEPIC, Tepic, Jan. & Feb., 1892 (*Edw. Palmer*, no. 1964). Originally from Santa Lucia in the Sierra Madre.

= = Leaves glabrous or puberulent beneath, only the nerves sometimes hispid or pilose, or the youngest minutely canescent-tomentulose.

a. Calyx in anthesis 3 to 4 mm. long.

1. Leaves green and glabrous on both sides: calyx campanulate and angulate below, enlarged-cupuliform above.

73. S. JURGENSENII, Briq. l. c. 144. Described from OAXACA.

2. Young leaves canescent-tomentulose at least beneath: calyx simply campanulate.

74. S. **mazatlanensis.** Stems slender, minutely puberulent or glabrate: leaves rhombic-ovate or deltoid-ovate, with long acuminate entire tips, and entire cuneate bases, otherwise coarsely appressed-serrate, thin, dark green above, pale beneath, 2 to 4 cm. long, 1 to 3 cm. wide, on slender petioles 2 cm. or less in length: racemes elongate, 0.5 to 2 cm. long; verticels 2–10-flowered, all somewhat remote, the lowest 1 to 1.5 cm. apart: bracts lance-subulate, caducous: pedicels 2 to 4 mm. long: calyx glabrate; the tube twice exceeding the lobes; upper lip broad-ovate, entire, blunt and submucronate, the lower with ovate-lanceolate acuminate lobes: corolla blue, 1 to 1.2 cm. long; galea pilose, nearly equalling the lip. — SINALOA, head of Mazatlan River, Jan., 1889 (*W. G. Wright*, no. 1298); Mazatlan, Dec. 29, 1894 (*F. H. Lamb*, nos. 351, 355). Lamb's no. 395 from Villa Union has thicker leaves and puberulent calyx, and may not belong with the Mazatlan plant, though it is nearer related to that than to any other species.

b. Calyx in anthesis 5 to 6 mm. long.

1. Branches cinereous: leaves cinereous-puberulent beneath, rhombic-ovate, coarsely crenate-serrate: racemes rather loosely flowered, 1 to 3 dm. long; verticels 2–15-flowered: calyx tubulose-campanulate, somewhat pilose on the nerves.

75. S. JALISCANA, Briq. l. c. 141. *S. albiflora*, Gray, Proc. Am. Acad. xxi. 408, not Mart. & Gal. *S. albiflora*, forma *caerulescens*, Gray, l. c. *S. albiflora*, var. *caerulescens*, Gray, acc. to Wats. Proc. Am. Acad. xxii. 445, in part. — Western Mexico. CHIHUAHUA, shady ravines near Batopilas, 1885 (*Edw. Palmer*, nos. 96, 154, 157): JALISCO, in ravines and by shaded roadsides, Guadalajara, Sept., 1886 (*Edw. Palmer*, no. 488); by streams near Guadalajara, Nov., 1888 (*C. G. Pringle*, no. 1798).

2. Leaves glabrous, glabrate, or merely pubescent on the nerves beneath.

○ Leaves and calyces strictly glabrous: leaves with long-acuminate tips: calyx with short broad generally mucronate-tipped lobes.

76. S. ALBIFLORA, Mart. & Gal. l. c. 76; Benth. in DC. l. c. 307; Gray, Syn. Fl. l. c. 370; Hemsl. l. c. 552; Briq. in Engl. & Prantl, l. c. — Arizona to Venezuela. SONORA, moist places, Magdalena, Oct., 1857 (*Geo. Thurber*, no. 907): VERA CRUZ, Tolosa, Dec. 24, 1898 (*C. C. Deam*, no. 57): OAXACA, Santo Domingo, alt. 290 m., June 12, 1895 (*E. W. Nelson*, no. 2668).

○ ○ **Lower faces of leaves and nerves of calyces pubescent.**

+ **Verticels crowded into a dense spiciform raceme 5 to 6 cm. long: stem shrubby.**

77. S. PTEROURA, Briq. Ann. Conserv. Jard. Bot. Genève, ii. 139. Described from COSTA RICA.

+ + **Verticels becoming remote.**

× **Branches slender, glabrate: calyx tubular-campanulate, not enlarged above.**

78. **S. Seemannii.** Frutescent (?): branches minutely pilose or glabrate, purplish; leaves elliptic-ovate, acuminate at the tip and at base to a slender petiole 1.5 to 3.5 cm. long, sharply serrate, above sparsely appressed-setulose, beneath minutely so on the nerves or glabrate, 4 to 7 cm. long, 2 to 4 cm. wide: raceme 1 dm. or less in length; verticels about 6-flowered, all a little remote, the lowest 1 cm. apart: bracts purple, lance-attenuate, persistent, slightly exceeding the setulose pedicels, 2 to 4 mm. long: calyx purple-tinged; the tube barely twice exceeding the lips; the upper lip broad-ovate, acuminate-subulate, the lower with lance-ovate acuminate lobes: corolla 1 cm. or so long, the tube a little exserted; galea pilose, equalling the lip: style bearded. — *S. flexuosa*, Seem. l. c. not Presl; Hemsl. l. c. 556, in part, with doubt. — North-western Mexico, in the Sierra Madre (*Seemann*).

× × **Stems herbaceous, stout, densely puberulent in decussating bands: calyx slightly flaring above.**

79. **S. fluviatilis.** Stems 1.5 m. or less high, very quadrangular: leaves rhombic-ovate, short-acuminate at tip, cuneate at base, crenate-serrate, the upper 5 to 9 cm. long, the lowermost broader, subtruncate at base, 1.5 dm. long, nearly as broad, puberulent above, especially on the nerves, cinereous beneath; petioles cinereous-puberulent, the lowest 5 cm. long, the others shorter: racemes slender, flexuous, the terminal becoming 2 dm. long; verticels 10–20-flowered, the lower remote, the lowest 1 cm. apart: bracts ovate, acuminate: pedicels filiform, becoming 2 to 3 mm. long: calyx green, strongly bilabiate, the tube twice exceeding the lips; the upper lip ovate, acuminate, entire, the lower with narrower attenuate lobes: corolla deep blue, pilose, 1 cm. long; the tube slightly exserted; galea about equalling the lip: style bearded. — MORELOS, by streams near Cuernavaca, alt. 1,540 m., May 16, 1898 (*C. G. Pringle*, no. 6850), Sept. 29, 1898 (*E. W. D. Holway*, no. 3028).

c. **Calyx in anthesis 7 to 9 mm. long.**

1. **Stem and leaves glabrous: the latter 1 to 1.3 dm. long, serrate.**

80. S. ALVAJACA, Oerst. Vidensk. Meddel. 1853, 38; Hemsl. l. c. 552. — Described from COSTA RICA. No specimen seen.

2. Stems and leaves pubescent, the stems glandular above.

O Primary leaves 4 to 5 cm. long, crenate.

81. S. RHOMBIFOLIA, Ruiz & Pav. Fl. Per. & Chil. i. 26, t. 36, f. b.; Benth. l. c. 310; Hemsl. l. c. 564. — Doubtfully reported from Mexico by Benth. l. c.

O O Primary leaves 1 dm. long, serrate.

82. **S. roscida.** Herbaceous? (only the top of the plant seen): stem closely glandular-puberulent above, the tip sparingly pilose: leaves very thin, elliptic-ovate, acuminate at both ends, coarsely and irregularly serrate, setulose-pilose above, sparingly so and minutely glandular-puberulent below; petioles slender, 5 cm. or less in length: racemes 1 to 1.5 dm. long; the verticels 6–12-flowered, all becoming remote, the lowest 3 to 4 cm. apart: bracts rhombic-ovate, long-acuminate, 6 to 8 mm. long: pedicels filiform, very glandular, 1 cm. or less in length: calyx glandular-puberulent, slightly setulose on the nerves, the long-attenuate lobes one half shorter than the cylindric-campanulate tube: corolla 1.8 cm. long, the tube exserted and slightly curved, glabrous, white; the blue lower lip somewhat exceeding the pilose galea: style included, bearded. — Northern Mexico. DURANGO, Chacala, alt. 920 m., March 5, 1899 (*E. A. Goldman*, no. 340).

+ Generally branching from the base, the stems slender and mostly decumbent: racemes long-peduncled. (Forms of *S. prunelloides* might be looked for here.)

++ Stems and leaves very setulose with long straight slender hairs.

= Leaves cuneate at base to short petioles or subsessile, obscurely crenate: bracts broad-ovate.

83. S. VERONICAEFOLIA, Gray in Wats. Proc. Am. Acad. xxii. 444. — JALISCO, on moist hillsides, Rio Blanco, June, 1886 (*Edw. Palmer*, no. 28); hillsides near Guadalajara, July 2, 1889 (*C. G. Pringle*, no. 2555).

= = Leaves truncate at base, coarsely crenate-dentate, long-petioled: bracts ovate-lanceolate.

84. **S. oreopola.** Stems repent at base, more or less assurgent, about 5 dm. long: leaves deltoid-ovate, dark green above, pale beneath, setulose on both surfaces, 2 to 3.5 cm. long, 1.5 to 3 cm. wide, on setulose petioles 1.5 to 2.5 cm. long: peduncles 7 to 10 cm. long; verticels 3–6-flowered, all becoming remote, the lowest 6 cm. apart: pedicels pubescent, 2 to 4 mm. long: calyx setulose, open-campanulate, strongly bilabiate; the broad purple upper lip blunt or acute, the lower with narrower

ovate-lanceolate acute lobes: corolla blue, 2 cm. long, the slightly pubescent tube twice exceeding the calyx; the blunt pilose galea one third as long as the broad lip: style densely bearded. — MORELOS, mountain side at 2,150 m. alt., near Cuernavaca, Aug. 9, 1898 (*C. G. Pringle*, no. 7643).

↔ ↔ Stems and leaves glandular-pilose, hardly setulose.

85. **S. villosa.** Stems 2.5 to 3 dm. high, glandular-pilose below, densely glandular-villous above and on the rhachis: leaves thick, pale green or cinereous, deltoid-ovate, mostly blunt at tip, subtruncate at base, entire or obscurely undulate, 1.5 to 3 cm. long, on cinereous-pubescent petioles 0.5 to 1.5 cm. long, the upper subsessile: peduncles 0.5 dm. long; verticels 3–6-flowered, all becoming remote, the lowest 2.5 to 3 cm. apart: bracts ovate, acuminate, setulose: pedicels slender, 2 to 3 mm. long: calyx blue-tinged, viscid, pilose-setulose, in anthesis 6 to 7 mm. long; the tube slightly longer than the lips; upper lips ovate, acuminate, entire, lower with two ovate acuminate lobes: corolla violet, 1.8 cm. long; the glabrous tube slightly exserted; the puberulent galea one third as long as the broad lip: style bearded. — SAN LUIS POTOSI, rare in the mountains, San Miguelito, 1876 (*Schaffner*, no. 678).

↔ ↔ ↔ Stems and leaves mostly glabrous or puberulent or only sparingly setulose.

= Upper lip of calyx tridentate.

a. Calyx-tube hispid: leaves from orbicular to ovate-triangular, 3 to 6 cm. long, 2 to 4 cm. broad.

86. S. GLECHOMAEFOLIA, HBK. l. c. 290, t. 141; Benth. in DC. l. c. 306; Hemsl. l. c. 556; Briq. l. c. — South central and southern Mexico. SAN LUIS POTOSI, alt. 1,850 to 2,460 m., 1878 (*Parry & Palmer*, no. 756): OAXACA, near Reyes, alt. 2,060 to 3,070 m., Oct. 20, 1894 (*E. W. Nelson*, no. 1794). Originally from near Guanajuato.

b. Calyx glabrous or minutely puberulent: leaves narrowly ovate-triangular, 1 to 1.75 cm. long.

87. S. FORRERI, Greene, Pittonia, i. 156. — DURANGO, Sierra Madre, west of Durango, alt. 2,500 m., Sept., Oct., 1881 (*A. Forrer*).

= = Upper lip of calyx entire, subulate-tipped; calyx densely white-pubescent with long fine viscid spreading hairs.

88. **S. prunifolia.** Stems puberulent, decumbent, assurgent only at the tips, 3 to 5 dm. long: leaves orbicular to obovate, rounded or acutish at tip, round or cuneate at base, crenate-serrate, the uppermost largest, 3 to 5 cm. long, 2.5 to 3.5 cm. broad, the lowest much smaller, dull green,

minutely puberulent above and on the nerves beneath, on puberulent petioles 0.2 to 1 cm. long: peduncles 7 to 10 cm. long, pubescent above with long fine spreading hairs; verticels 4–8-flowered, all becoming remote, the lowest 1.5 to 2 cm. apart: bracts narrow-ovate, acuminate: pedicels 2 to 3 mm. long: calyx in anthesis 5 to 6 mm. long, the tube twice exceeding the subulate-tipped lobes: corolla 1.3 to 1.5 cm. long, the glabrous tube one half exceeding the calyx; galea puberulent, half as long as the dark blue lip. — TEPIC, Santa Gertrudis, in the Sierra Madre, Aug. 8, 1897 (*J. N. Rose*, no. 3407).

D. Axilliflorae, Benth. Small much branched and depressed suffrutescent plants: the flowers borne in the axils of foliar leaves: corolla-tube scarcely ventricose.

* Leaves oblong-linear oblanceolate or spatulate, 0.5 to 1.5 cm. long, entire, canescently rough-hispid.

89. S. AXILLARIS, Moc. & Sess. in Benth. Lab. 270; Benth. in DC. l. c. 313; Hemsl. l. c. 553; Briq. l. c. — South central Mexico. Without locality (*Coulter*, no. 1118): SAN LUIS POTOSI, in the mountains, 1876 (*Schaffner*, no. 648), alt. 1,850 to 2,500 m., 1878 (*Parry & Palmer*, no. 698): GUANAJUATO, 1893 (*A. Dugès*, no. 228 A).

* * Leaves cuneate-obovate, 5 to 7.5 mm. long, 3-toothed, appressed-setulose.

90. S. CUNEIFOLIA, Benth. Lab. 270, & in DC. l. c.; Hemsl., l. c. 555; Briq. l. c. — Southern Mexico. HIDALGO, bare hills above Pachuca, alt. 2,600 m., July 18, 1898 (*C. G. Pringle*, no. 6905). Originally described from Oaxaca.

E. Candicantes, Benth. Shrubs: leaves oblong or lanceolate, rarely cordate, or when ovate not cordate, beneath tomentose or densely fine canescent, rarely pale and glabrate. (Some species approaching the *Scorodoniae*, others the *Erianthae*.)

* Calyx canescent short-pubescent or tomentose, not densely woolly.

+ Leaves entire or essentially so. (Reduced forms of *S. chamaedryoides* may be looked for here.)

++ Leaves sessile or subsessile, narrow-oblong, strongly revolute.

91. **S. Coulteri.** Branches ligneous, covered with gray-brown bark and numerous approximate leaf-scars: leaves densely cinereous-tomentulose with stellate hairs, strongly revolute, blunt at tip, truncate or subcordate at base, 1 to 1.5 cm. long, 2 to 4 mm. wide: racemes 2 to 3 cm. long; the rhachis pilose with long branching hairs; verticels about 6-flowered, slightly remote: calyx tubular-campanulate, glandular-pilose,

in anthesis 6 to 7 mm. long; the tube twice or thrice exceeding the lance-subulate teeth; upper lip tridentate: corolla 1.2 cm. long, short-pilose, the galea about equalling the lip: style slightly bearded. — Mexico, without locality (*Coulter*, no. 1120).

++ ++ Leaves narrowly triangular-ovate, truncate or slightly cordate at base, on thickish winged petioles, closely and densely white-pubescent beneath.

92. S. CANDICANS, Mart. & Gal. l. c. 61; Benth. l. c. 315; Hemsl. l. c. 554; Briq. l. c. — PUEBLA, limestone hills between Tehuacan and Esperanza, alt. 2,000 m., Dec. 21, 1895 (*C. G. Pringle*, no. 6245). Essentially the type station of the species.

++ ++ ++ Leaves narrow-ovate or oblong, attenuate at base to short petioles, or the upper subsessile.

= Calyx ovate tubular, with short blunt lobes, glandular-pubescent, in anthesis 5 to 6 mm. long: leaves closely white-pubescent beneath.

93. S. THYMOIDES, Benth. Lab. 255, & in DC. l. c. 314; Hemsl. l. c. 566; Briq. l. c. — Southern Mexico. PUEBLA, limestone hills between Tehuacan and Esperanza, alt. 2,000 m., Dec. 21, 1895 (*C. G. Pringle*, no. 6251): OAXACA, Mitla (*G. Andrieux*, no. 150); vicinity of Coixtlahuaca, alt. 2,150 to 2,300 m., Nov. 12, 1894 (*E. W. Nelson*, no. 1915). Species based in part on Andrieux's plant.

= = Calyx tubular-campanulate, with acuminate lobes, not glandular-pubescent, in anthesis 6 to 8 mm. long: leaves sparingly stellate puberulent or glabrate.

a. Leaves oblong, 1 to 2.5 cm. long, the uppermost subsessile.

1. Leaves finely stellate-puberulent at least when young.

94. **S. coahuilensis.** Freely branching mostly from the stout woody base; branches assurgent, 0.5 to 7 dm. high; bark pale brown, finely stellate-puberulent or glabrate: leaves confined mostly to the lower portions of the branches: racemes elongated, becoming 0.5 to 3.5 dm. long, the rhachis often glandular-puberulent; verticels mostly 2-flowered, all remote, the lowest 2 to 3 cm. apart: bracts ovate-oblong, acuminate, caducous: pedicels filiform, 2 to 4 mm. long: calyx granulose-puberulent; tube twice exceeding the ovate-lanceolate subequal lobes; upper lip entire: corolla 1.5 cm. long, blue with white centre; the glabrous tube nearly twice exceeding the calyx; the slightly pilose galea one half as long as the broad lower lip. — *S. chamaedryoides*, Wats., Proc. Am. Acad. xviii. 137, in part, not Cav. — COAHUILA, rocky hill, Saltillo, 1878 (*Parry*, no. 29), May, 1898 (*Edw. Palmer*, no. 194); Parras, June, 1880, and Lerios, July, 1880 (*Edw. Palmer*, nos. 1072, 1064).

2. Leaves glabrous.

95. S. LYCIOIDES, Gray, Proc. Am. Acad. xxi. 408. — CHIHUAHUA, cañons, Santa Eulalia Mts., May 1, 1885 (*C. G. Pringle*, no. 52).

b. Leaves ovate or ovate-oblong, 3 to 7 mm. long, all slender petioled.

96. **S. serpyllifolia.** Erect (?), 5 or 6 dm. high, the ascending branches brown, short-pubescent in decussating bands with minute white spreading or slightly recurved hairs; leafy to the inflorescence, the internodes 1 to 1.5 cm. long: racemes becoming 1 to 2 dm. long; verticels 2–6-flowered, all becoming remote, the lowest 1 cm. or so apart: bracts ovate, acuminate, ciliate, caducous: calyx short-hispidulous on the veins; tube thrice exceeding the ovate lobes; upper lip blunt, entire, lower with 2 short acuminate lobes: corolla 1.2 cm. long; the glabrous tube one-half longer than the calyx; the lower lip slightly exceeding the pilose galea: style slightly bearded. — *S. chamaedryoides*, Wats. Proc. Am. Acad. xviii. 137, in part, not Cav. — SAN LUIS POTOSI, without locality, alt. 1,850 to 2,460 m., 1878 (*Parry & Palmer*, no. 751).

+ + Leaves crenate or crenate-serrate. (A form of *S. scorodoniaefolia* may be looked for here.)

++ Calyx lobes normal, not conspicuously broadened.

= Stems chalky-white with very close hirsute indumentum: leaves ovate, thin, slender-petioled, minutely white stellate beneath: verticels 6–10-flowered: calyx stellate-tomentulose; the tube thrice exceeding the short ovate lobes; the upper lip blunt, erect.

97. S. CEDROSENSIS, Greene, Bull. Cal. Acad. i. 212. — LOWER CALIFORNIA, Cedros Island, March, 1889 (*Edw. Palmer*, no. 684), March to June, 1897 (*A. W. Anthony*, no. 294); Magdalena Bay, Jan. 14, 1889 (*T. S. Brandegee*).

= = Stems and leaves (at least beneath) more or less cinereous-tomentulose with stellate hairs: verticels 2–6-flowered: calyx-tube twice exceeding the acuminate lobes.

98. S. CHAMAEDRYOIDES. Cav.[1] Leaves elliptic-ovate or narrowly deltoid-ovate, green above, slender-petioled, 1 to 2.5 cm. long. — Ic. ii. 77, t. 197; Sims, Bot. Mag. t. 808; Benth. l. c. 314; Hemsl. l. c. 554; Briq. l. c. *S. chamaedrifolia*, Andr. Bot. Rep. vi. t. 416. *S. Chamaedrys*,

---

[1] **S. ramosissima.** Similar to *S. chamaedryoides*, very freely branching above: young branches slightly canescent with short spreading or somewhat recurved hairs: leaves paler beneath than above, more or less scabrous on both faces with short stiff simple hairs: calyx with similar pubescence on the nerves. — *S. chamaedryoides*, Gray, Syn. Fl. l. c. 371, not Cav. — Cañons of the Rio Grande, S.W. TEXAS, 1849 (*C. Wright*, no. 472 a): Organ Mts., NEW MEXICO, 1881 (*G. R. Vasey*).

Willd. Hort. Berol. i. 29, t. 29. — Central Mexico. ZACATECAS, plains, La Honda Station, Aug. 18, 1890 (*C. G. Pringle*, no. 3170): SAN LUIS POTOSI, alt. 1,850 to 2,460 m., 1878 (*Parry & Palmer*, no. 753): HIDALGO, bare hills above Pachuca, alt. 2,600 ft., July 18, 1898 (*C. G. Pringle*, no. 6907): MEXICO, mountains near Mexico and Guadalupe, Aug. 24, 1865 (*Bourgeau*, no. 855).

Var. **isochroma**. Leaves reduced, 0.5 to 1.5 cm. long, short-petioled or subsessile, mostly crowded, canescent on both faces. — SAN LUIS POTOSI, in the mountains, San Rafael and San Miguelito, 1876 (*Schaffner*, nos. 663, 664); without locality, alt. 1,850 to 2,460 m., 1878 (*Parry & Palmer*, nos. 750, 751½).

= = = Stems with spreading pubescence: leaves 2 to 3 cm. long; blades little exceeding the petioles.

99. S. PAUCIFLORA, HBK. l. c. 303; Benth. l. c. 315; Hemsl. l. c. 563. — A doubtful species from "New Spain."

= = = = Of this section but not identified.

S. SPICATA, R. & S. Syst. Mant. i. 202 (*S. pulchella*, HBK. l. c. 288, t. 140, not DC. *S. pomifera*, Sessé & Moc. l. c. 7, ex. char., not L.) and S. BREVIFLORA, Moc. & Sessé in Benth. Lab. 274, species described from "New Spain" are placed by Bentham in this section. *S. spicata*, Gray, Syn. Fl. l. c. 461, is very different from the plate of *S. pulchella*, HBK.

++ ++ Calyx funnelform, the lobes becoming ampliate.

= Leaves ovate or ovate-orbicular, dark green above, much paler beneath, regularly crenate.

100. S. BALLOTAEFLORA, Benth. Leaves rugose, densely white-tomentulose beneath, 0.5 to 3 cm. long, rarely larger: racemes 0.5 to 8 cm. long. — Lab. 270, & in DC. l. c. 313; Torr. Bot. Mex. Bound. 131; Gray, l. c.; Hemsl. l. c. 553; Briq. l. c. *S. laxa*, Benth. l. c. — Texas to San Luis Potosi. Mexico, without locality (*Gregg*, no. 322): COAHUILA, Monclova, Aug., 1880, Parras, June, 1880, Lerios, July, 1880, Saltillo, May, 1898 (*Edw. Palmer*, nos. 1069, 1067, 1068, 107): TAMAULIPAS, 1843 (*Berlandier*, no. 3186): SAN LUIS POTOSI, San Rafael, 1876, (*Schaffner*, no. 670); near Matehuala, June 18, 1898 (*E. W. Nelson*, no. 4527).

Var. **Eulaliae**. Leaves large, 3 cm. long, broad-ovate, rugose, very slightly pubescent and hardly canescent beneath: racemes very numerous, 4 to 9 cm. long. — CHIHUAHUA, Santa Eulalia Mts., Sept. 1, 1885 (*C. G. Pringle*, no. 659).

Var. **pinguifolia.** Leaves large, as in the last, scarcely rugose, very pale beneath with a close very minute indumentum, not tomentulose, greasy to the touch: racemes all many-flowered. — NEW MEXICO, 1851–52 (*C. Wright*, no. 1524): ARIZONA, San Francisco Mts., back of Clifton, Sept. 3, 1880 (*E. L. Greene*, no. 300).

= = Leaves very pale on both surfaces, thick, hardly rugose, greasy to the touch, irregularly crenate.

101. S. PLATYCHEILA, Gray, Proc. Am. Acad. viii. 292, & Syn. Fl. l. c. — LOWER CALIFORNIA, Carmen Island, 1870, Nov. 1890 (*Edw. Palmer*, nos. 7, 878).

* * Calyx densely woolly: verticels in short spiciform racemes: lip of corolla distinctly exceeding the galea (otherwise approaching the *Erianthae*).

102. **S. confinis.** Branches canescent with fine stellate pubescence, leafy to the inflorescence: leaves oblong, blunt or acutish, rounded-truncate or subcuneate at base, very short-petioled, thick and rugulose especially along the closely crenulate margin, closely canescent on both surfaces, or ferrugineous-tinged beneath, 1.5 to 4.5 cm. long, 0.5 to 2 cm. wide: spiciform racemes simple or slightly paniculate, 1 to 4 cm. long, lowest verticels slightly remote: bracts large, broad-ovate, acuminate, somewhat persistent, 0.5 to 1 cm. long, stellate-tomentose: calyx dark blue, mostly hidden by dense white-lanate pubescence: corolla blue, scarcely 1 cm. long. — *S. spicata*, Gray, l. c. 461, not R. & S. — Southern Arizona and adjacent Mexico. ARIZONA, mountain pass near Fort Huachuca, 1882 (*Lemmon*, no. 2861): SONORA, Fronteras, alt. 1,400 m., Sept. 25, 1890 (*C. V. Hartman*, no. 43).

F. Scorodoniae, Benth. Shrubs with ovate (in *S. thyrsiflora* ovate-lanceolate) rugose leaves generally cordate, rarely cuneate, at base.

* Leaves white-tomentose beneath with simple hairs.

+ Leaves very rough-rugose above, mostly broad-ovate (except in variety of the first species) with obtuse or blunt tips.

++ Pedicels very short, at most 3 mm. long: racemes rather dense, often branching: calyx somewhat cuneate-campanulate, in anthesis 4 to 5 mm. long, with short flaring obtuse lobes.

= Pubescence of calyx glandular-villous.

103. S. SCORODONIAEFOLIA, Poir. Leaves ovate, subcordate. — Suppl. v. 46: Benth. l. c. 316; Hemsl. l. c. 565; Briq. l. c. *S. melissodora*, Lag. Gen. & Spec. Nov. 2. *S. hirta*, Schranck, Syll. Pl. Soc. Ratisb. ii. 60? according to Benth. *S. scorodonia*, Benth. Lab. 264. — Central and southern Mexico. SAN LUIS POTOSI, alt. 1,850

to 2,460 m., 1878 (*Parry & Palmer*, no. 730): MEXICO, Guadalupe June 21, 1865 (*Bourgeau*, no. 295): OAXACA, Valley of Cuicatlan, alt. 2,000 to 2,460 m., Nov. 10, 1894 (*E. W. Nelson*, no. 1898); San Juan del Estado, alt. 1,800 m., Oct. 20, 1895 (*L. C. Smith*, no. 930); Pápalo, Cuicatlan, alt. 1,650 m., Dec. 9, 1895 (*V. González*, no. 42).

Var. **crenaea.** Leaves narrower, oblong-lanceolate, blunt, rounded or subcuneate at base. — *S. scorodonia*, Benth. Pl. Hartw. 20, not Benth. Lab. 264. — A northern narrow-leaved extreme. AGUAS CALIENTES (*Hartweg*, no. 164): CHIHUAHUA, southwestern section, without locality, 1885 (*Edw. Palmer*).

= = Pubescence of calyx long-villous, not glandular.

104. S. LASIANTHA, Benth. Lab. 276, & in DC. l. c. 321; Hemsl. l. c. 559; Briq. l. c. — Range of the last from which it differs only in the more villous glandless calyx. Perhaps only a variety of that. DURANGO, Ramos to Inde, Aug., 1898 (*E. W. Nelson*, no. 4679): SAN LUIS POTOSI, in the mountains, San Rafael, 1876 (*Schaffner*, no. 671); without locality, alt. 1,850 to 2,460 m., 1878 (*Parry & Palmer*, no. 731); limestone ledges, San José Pass, July 23, 1890, and limestone hills, Las Canoas, Oct. 8, 1890 (*C. G. Pringle*, nos. 3206, 3273): HIDALGO, calcareous hills near Tula, alt. 2,160 m., Oct. 5, 1896 (*C. G. Pringle*, no. 6538): OAXACA, near Dominguillo, alt. 2,000 m., Oct. 3, 1894 (*E. W. Nelson*, no. 1595). Placed by Bentham and by Briquet in the section *Erianthae*.

++ ++ Pedicels longer, 3 to 9 mm. long: racemes loosely flowered; verticels remote: calyx tubular-campanulate, in anthesis 6 mm. or more long.

= Calyx purplish-violet, glandular-villous, in anthesis nearly 1 cm. long: lower lip of corolla almost black; tube and galea pale.

105. S. SEMIATRATA, Zucc. Abhandl. Baier. Akad. Wiss. i. 298; Benth. in DC. l. c. 316; Hemsl. l. c. 565; Briq. l. c. — OAXACA, without locality, June (*Andrieux*, no. 149); calcareous hills, Las Sedas, alt. 1,850 m., Aug. 2, 1894 (*C. G. Pringle*, no. 4763), alt. 2,150 m., June 27, 1895 (*L. C. Smith*, no. 413); near city of Oaxaca, alt. 1,600 to 2,100 m., Oct. 2, 1894 (*E. W. Nelson*, no. 1511).

= = Calyx green (or blue-tinged), glandular-puberulent and minutely hispidulous on the nerves, in anthesis about 6 mm. long: coralla blue.

106. **S. Gonzalezii.** Branches very slender, somewhat villous, the youngest parts and the rhachises glandular-puberulent: leaves broad-ovate, bluntish at tip, truncate or subcordate at base, green and very rugose, slightly pubescent above, white-villous beneath, crenulate, 1 to

2.5 cm. long, 0.75 to 1.75 cm. broad, on villous petioles 1 cm. or less in length: racemes simple, 0.5 to 1.5 cm. long; verticels 3–8-flowered, all remote, the lowest 2 to 2.5 cm. apart: pedicels 3 to 5 mm. long, glandular-puberulent: calyx tubular-campanulate; the tube twice or thrice exceeding the ovate mucronate lobes; upper lip entire: corolla deep blue, 1.5 cm. long; the glabrate tube twice exceeding the calyx; the pilose galea slightly exceeding the dark lip: style bearded. — OAXACA, El Parián-Etla, alt. 370 m., Nov., 1898 (*V. González* & *C. Conzatti*, no 903).

+ + Leaves less rugose, narrow-ovate, mostly acuminate at tip.

++ Flowers in small cymes forming a terminal thyrsus: leaves ovate-lanceolate.

107. S. THYRSIFLORA, Benth. Bot. Sulph. 151, & in DC. l. c.; Hemsl. l. c. 566; Briq. l. c. — Southwestern Mexico, Tepic to Michoacan. JALISCO, vicinity of Mascota and San Sebastian, alt. 1170 to 1540 m., March, 1897 (*E. W. Nelson*, nos. 4057, 4081): MICHOACAN, mountains near Patzcuaro, Nov. 10, 1890, Dec. 21, 1891 (*C. G. Pringle*, nos. 3593, 4097). Originally from TEPIC.

++ ++ Flowers in simple or more or less branched generally paniculately or virgately disposed racemes.

= Branches short-pilose with recurved spreading hairs.

a. Calyx tubular, in fruit 5 mm. long, the tube four times exceeding the very short broad lobes.

108. S. ALAMOSANA, Rose, Contrib. U. S. Nat. Herb. i. 110. — SONORA, Sierra de los Alamos, 1890 (*Edw. Palmer*, no. 345).

b. Calyx campanulate, in fruit 6 to 7 mm. long, the tube twice exceeding the narrower lobes.

109. S. CHAPALENSIS, Briq. Ann. Conserv. Jard. Bot. Genève, ii. 145. — JALISCO, rich wooded cañons, mountains near Lake Chapala, Nov. 22, 1892 (*C. G. Pringle*, no. 4351).

= = Branches pubescent with ascending soft hairs.

110. **S. multiramea.** Stems about 1 m. high, freely paniculate-branched, the upper branches leafless and bearing racemes: leaves narrow-ovate, acuminate, rounded or subcordate at base, somewhat rugose and scabrous-hispidulous above, densely tomentose beneath, short-petioled, 2 to 5 cm. long, 1 to 2.5 cm. broad: inflorescence paniculate; lower branches leafy and axillary, upper naked; terminal racemes 1.2 dm. or less in length, the others shorter; verticels 2–12-flowered, all becoming remote: bracts lance-subulate, minute, early deciduous: pedicels 2 to

4 mm. long, spreading: calyx tubular, in anthesis 3.5 to 4 mm. long, appressed-pilose; the tube 3 or 4 times as long as the short blunt lobes: corolla blue, 1 to 1.2 cm. long; the glabrous tube one half longer than the calyx; the pilose galea twice exceeded by the exteriorly pilose lip: style bearded. — Southern Mexico. OAXACA, near city of Oaxaca, alt. 2,300 to 2,920 m., Sept., 1894 (*E. W. Nelson*, no. 1448), alt. 1,850 m., Oct. 25, 1894 (*C. G. Pringle*, no. 6013); near Reyes, alt. 1,700 to 2,060 m., Oct. 20, 1894 (*E. W. Nelson*, no. 1783); mountains of Jayacatlan, alt. 1,300 m., Nov. 4, 1894, alt. 2,000 m., Oct. 18, 1895 (*L. C. Smith*, nos. 272, 860); near Chilpanciugo, alt. 2,770 to 3,140 m., Dec. 24, 1894 (*E. W. Nelson*, no. 2235): CHIAPAS, without locality (*Ghiesbreght*, no. 764).

* * Leaves, at least when young, pale beneath with stellate hairs.

+ Calyx densely invested with close stellate indumentum, not long woolly (except at the base in no. 114).

++ Leaves 1 to 1.5 cm. long.

111. S. FRUTICULOSA, Benth. Lab. 721, & in DC. l. c. 315; Hemsl. l. c. 556; Briq. in Engl. & Prantl, l. c. — OAXACA, near city of Oaxaca (*Andrieux*, no. 151).

++ ++ Leaves 2 to 6 cm. long.

= Branchlets and nerves of young leaves with sulphur-yellow indumentum.

112. **S. Conzattii.** Branching above, the younger parts densely stellate-tomentulose: leaves ovate, 1.5 to 6 cm. long, 0.75 to 3.5 cm. broad, rounded at tip, rounded-truncate or subcuneate at base, dark green and very rugose above, pale and very strongly reticulate-rugose beneath; margin finely crenulate; petioles 1.5 cm. or less in length: racemes spiciform, 2 to 6 cm. long, at first dense, the 3–many-flowered verticels later becoming a little remote, all the parts more or less red-punctate: bracts ovate-acuminate, exceeding the calyx, white-tomentose at base, yellowish at tip, soon deciduous: calyx ovate-campanulate, densely tomentose with pale blue freely-branching hairs, with very short blunt inconspicuous lobes: corolla 1.2 cm. long, blue, red-punctate and whitened above with stellate tomentum; tube somewhat exserted; the galea hardly equalling the lip: style bearded. — OAXACA, El Parián-Etla, alt. 370 m., Nov. 1898 (*V. González & C. Conzatti*, no. 902).

= = Branchlets and lower faces of leaves with white indumentum.

a. Leaves broad-ovate, sharply crenate-dentate: calyx-lobes blunt.

113. **S. pruinosa.** Rather stout shrub with pale brown bark, the younger parts densely pruinose with stellate hairs: leaves 2.5 to 5 cm.

long, 1.5 to 3.5 cm. wide, blunt at tip, rounded or subcuneate at base, green very rugose and glabrate above, very white beneath, irregularly crenate-dentate; petioles 1.25 cm. or less in length: racemes 1 dm. or less long; verticels many-flowered, rather crowded, the lowest 1 to 1.5 cm. apart; all the parts red-punctate; rhachis pruinose-pubescent: bracts ovate-acuminate, bluish, finely stellate-pubescent: calyx ovate-campanulate, closely pruinose-pubescent, bluish-tinged, in anthesis 4 to 5 mm. long; the tube twice or thrice exceeding the deltoid blunt lobes: corolla 1.2 cm. long, pruinose-stellate; the tube one half longer than the calyx; the galea about equalling the lip: style bearded. — JALISCO, road between Mesquitec and Monte Escobedo, Aug. 26, 1897 (*J. N. Rose*, no. 2601).

b. Leaves oblong-ovate, bluntly crenate: calyx-teeth subulate.

114. **S. Goldmanii.** Stem stout, 6 or 7 dm. high, herbaceous, or fruticose at base, puberulent, with numerous ascending branches above: leaves dull-green, slightly rugose above, cinereous and red-punctate beneath, 1 dm. or less long, bluntish at tip, rounded-cuneate to petioles 2 cm. or less in length: racemes 0.5 to 1.5 dm. long; verticels 6–12-flowered, the lower 2 cm. apart, the upper approximate; rhachis lanate: bracts lance-ovate, caducous: calyx in anthesis 5 to 6 mm. long, lanate at base, the deltoid subulate-tipped lobes one half as long as the tube: corolla red-punctate, 1.5 cm. long; the tube somewhat exserted, glabrous below; the lips stellate-pilose without, the lower exceeding the galea: style barely exserted, bearded. — Northwestern Mexico. CHIHUAHUA, near Batopilas, alt. 1690 to 2000 m., Oct. 4, 5, 1898 (*E. A. Goldman*, no. 214).

+ + Calyx blue, invested in long white wool: leaves becoming glabrate, conspicuously red-punctate beneath.

115. S. RUBROPUNCTATA, Robinson & Fernald, Proc. Am. Acad. xxx. 121. — SONORA, in the cañon, Huehuerachi, Dec. 12, 1890 (*F. E. Lloyd*, no. 451).

* * * Leaves glabrous, or the youngest slightly puberulent on the nerves beneath.

116. **S. Nelsonii.** Shrub with smooth reddish-brown bark, the younger branchlets slightly puberulent: leaves ovate, blunt or acutish at tip, rounded at base, 1.5 to 5 cm. long, 1 to 3 cm. broad, dull green and obscurely rugose above, paler beneath, crenate-serrate: petioles slender, puberulent, 1 cm. or less in length: inflorescence more or less paniculate; the racemes 1 dm. or less long, the upper terminating leafless branches; verticels 6–12-flowered, becoming a little remote, the lowest 1 to 2 cm.

apart: calyx cuneate-campanulate, resembling that of *S. scorodoniaefolia*, densely short white-villous, in anthesis 5 to 6 mm. long; the tube three or four times exceeding the short blunt lips: corolla blue, pilose, 1.2 cm. long; the tube included or barely exserted; the lip slightly exceeding the galea: style bearded. — PUEBLA, between Acatlan and Piaxtla, alt. 1,230 to 1,380 m., Nov. 22, 1894 (*E. W. Nelson*, no. 2005). The calyx has a strong ginger-like fragrance.

* * * * Leaves pubescent beneath: plant not identified.

117. S. KEERLII, Benth. Lab. 263, & in DC. l. c. 316, with ovate cordate very rugose leaves canescent-tomentose beneath, and with dense paniculate-branched racemes, the calyx pilose-hirsute, not canescent-tomentose, described from Tlalpujahua, MICHOACAN, and from Regla.

G. Cordifoliae, Benth. Tall herbs or shrubs (ours herbs) with broad cordiform herbaceous leaves green or pale beneath and cordate at base, at least the lowermost long-petioled. (*S. purpurascens* & *S. Martensii* might be looked for here.)

* Stems pilose-hispid: leaves crenate, pale beneath: calyx pilose-hispid, more or less glandular.

118. S. AMARISSIMA, Ort. Dec. 4; Edw. Bot. Reg. iv. t. 347; Benth. l. c. 317; Hemsl. l. c. 553; Briq. l. c. 280. *S. circinata*, Cav. Ic. iv. 9, t. 318. *S. amara*, Jacq. Hort. Schoenb., iii. 2, t. 255. *S. hirsuta*, Sessé & Moc. l. c. 8. *S. amethystina*, Donnell Smith, Enum. Pl. Guat. i. 35, ii. 62, in part, not Smith. — *S. cyanea*, Donnell Smith l. c. iii. 67, iv. 125, not Benth. — A common species from Central Mexico to Central America and Panama. Without locality (*Uhde*, no. 791): SAN LUIS POTOSI, alt. 1,850 to 2,460 m., 1878 (*Parry & Palmer*, no. 752): HIDALGO, hills above Pachuca, alt. 2,550 m., July 18, 1898 (*C. G. Pringle*, no. 6914): MEXICO, Guadalupe, Aug. 17, 1865 (*Bilimek*, no. 304); Valley of Mexico, May 11, 1865 (*Bourgeau*, no. 125, in part), Sept. 19, 1889 (*C. G. Pringle*, no. 2817); Rio Hondo Cañon, Aug. 22, 1890 (*C. G. Pringle*, no. 3153): MICHOACAN, Tlalpujahua (*Graham*): OAXACA, Monte Alban, alt. 1,790 m., July 20, 1894 (*L. C. Smith*, no. 171); Valley of Oaxaca, alt. 1,540 to 1,790 m., 1894 (*E. W. Nelson*, nos. 1103, 1289): GUATEMALA, Coban, Dept. Alta Verapaz, alt. 1,320 m., July, 1885, and Santa Rosa, Dept. Baja Verapaz, alt. 1,540 m., July, 1887 (*H. von Tuerckheim* in exsicc. J. D. Smith, nos. 110, 1192); San Lucas, Dept. Zacatepéquez, alt. 1,700 m., April, 1890 (*J. D. Smith*, no. 2187); Estanzuela, Dept. Santa Rosa, alt. 770 m., Aug., 1892, Santa Rosa, alt. 925 m., May, 1893, and Laguna de Ayarza, Dept. Ja-

lapa, alt. 2,460 m., Sept., 1892 (*Heyde & Lux* in exsicc. J. D. Smith, nos. 4050, 4564, 4056 : PANAMA, Gatun (*Sutton Hayes*).

* * Stems puberulent above and slightly short-pilose on the angles, densely woolly at the nodes: leaves crenate-serrate: calyx puberulent and minutely pilose.

119. S. SIDAEFOLIA, Mart. & Gal. l. c. 67; Benth. l. c. 318; Hemsl. l. c. 565; Briq. l. c. — OAXACA, wet ravines, Sierra de San Felipe, alt. 2,600 m., Jan. 3, 1895 (*C. G. Pringle*, no. 5643). Originally collected in the cordillera of OAXACA.

H. Rudes, Benth. Herbs with ovate leaves cordate at base, subsessile or very short-petioled.

* Bracts ovate-lanceolate, 1 to 1.5 cm. long, firm and persistent: calyx in anthesis 1 cm. long: corolla crimson, 3 cm. long: plant weak, pilose-hispid, the leaves firm and lucid.

120. S. SESSILIFOLIA, Gray in Wats. Proc. Am. Acad. xxii. 445; Briq. Ann. Conserv. Jard. Bot. Genève, ii. 152. — JALISCO, bottom of ravine, Rio Blanco, July, 1886 (*Edw. Palmer*, no. 184); ravines near Guadalajara, July 1, 1889 (*C. G. Pringle*, no. 3058). In its corolla approaching the *Fulgentes*.

* * Bracts minute, caducous.

+ Stems simple or subsimple from woody base, more or less pilose: leaves green on both faces, blunt or obtuse: calyx in fruit 7 to 8 mm. long.

121. S. PLATYPHYLLA, Briq. l. c. 50. *S. amarissima*, Wats. l. c., not Ort. — JALISCO, hills, Rio Blanco, July, 1886 (*Edw. Palmer*, no. 183); hillsides near Guadalajara, July 3, 1889 (*C. G. Pringle*, no. 2560).

+ + Stem freely branching above, pilose with somewhat recurved hairs: leaves canescent, pilose beneath, acuminate: fruiting calyx about 5 mm. long.

122. S. NEPETOIDES, HBK. l. c. 299, t. 150. *S. amarissima*, Benth. l. c. 317, as syn.; Hemsl. l. c. 553, as syn.; not Ort. — South central Mexico. MORELOS, mountain side near Cuernavaca, alt. 2,160 m., Aug. 9, 1898 (*C. G. Pringle*, no. 7612). Originally from GUANAJUATO.

§ 4. ERIANTHAE, Benth. Shrubs generally with rugose leaves (not in *S. populifolia*). Calyx densely lanate. Lips of the corolla subequal or the galea longer; the tube a little exserted, straight, ventricose or enlarged above.

* Pubescence of calyx purple or rose-colored.

+ Leaves lanceolate or linear-lanceolate, green above, white-lanate beneath: raceme elongated, 4 dm. or less in length: corolla white, lanate.

123. S. LEUCANTHA, Cav. Ic. i. 16, t. 24; Hook. Bot. Mag. t. 4318; Benth. l. c. 321; Hemsl. l. c. 560; Briq. in Engl. & Prantl, l. c. *S.*

bicolor, Sessé & Moc. l. c. 8. — Coahuila to Oaxaca, often cultivated. Without locality (*Graham*): COAHUILA, garden at Saltillo, 1848–49 (*Gregg*, no. 597): ZACATECAS, in plaza, Monte Escobedo, Aug. 27, 1897, and on the Sierra de los Morones, near Plateado, Sept. 1, 1897 (*J. N. Rose*, nos. 2641, 3627): SAN LUIS POTOSI, near Santa Maria, 1876 (*Schaffner*, no. 669).

+ + Leaves ovate, subcordate: corolla reddish.

++ Leaves very rugose, 2.5 to 4 cm. long, on short petioles 4 to 8 mm. long.

124. S. LANTANAEFOLIA, Mart. & Gal. l. c. 69; Benth. l. c. 322; Hemsl. l. c. 559; Briq. l. c. — PUEBLA, Atlixco, July 25–Aug. 1, 1893 (*E. W. Nelson*). Originally from PUEBLA. Seaton's no. 500 from Maltrata, VERA CRUZ, is near this species but not satisfactorily referable to it.

++ ++ Leaves hardly rugose, 0.5 to 1 dm. long, on petioles 1.5 to 2.5 cm. long.

125. **S. populifolia.** Shrub with gray bark: branchlets and petioles lanate with yellowish white pubescence: leaves ovate, bluntly acuminate, crenulate, green and puberulent above, white-velutinous beneath: raceme 1.5 dm. or less in length, simple or with a tendency to branch; verticels about 6-flowered, becoming a little remote: bracts ovate, acuminate, 1 cm. long, purple-lanate without, soon deciduous: calyx campanulate, in anthesis 1.8 cm. long, the tube twice or thrice exceeding the deltoid acuminate lobes; upper lip entire, lower 2–lobed: corolla pilose, reddish, 3.5 cm. long, the galea slightly exceeding the lip: long-exserted portion of style glabrous. — JALISCO, Bolaños, Sept., 1897 (*J. N. Rose*, no. 2862).

* * Pubescence of dorsal and ventral portions of calyx dark red, of the sides brilliant yellow: corolla dark red; the lip much shorter than the galea: leaves ovate-lanceolate, acuminate at base, very rugose above.

126. S. PITTIERI, Briq. Bull. Soc. Bot. Belg. xxx. pt. 1, 237. Described from COSTA RICA, and doubtfully referred by its author to this group.

§ 5. MACROSTACHYAE, Benth. Pubescent large-leaved shrubs or herbs. Racemes dense, thick, with large thick firm leaf-like persistent bracts. Corolla blue or white, twice or thrice as long as the calyx.

* Villous herb: leaves ovate, rounded or subcuneate to a winged petiole: verticels very many-flowered, somewhat remote.

127. S. CLINOPODIOIDES, HBK. l. c. 294, t. 145; Benth. l. c.; Hemsl. l. c. 554; Briq. l. c. *S. parquerensis*, Moc. & Sess. in Benth. Lab. 273;

Benth. in DC. l. c.; Hemsl. l. c. 562; Briq. l. c. *S. patzcuarensis*, Sess. & Moc. Pl. Nueva España, ed. 2, 8. — Sierra Madre of Western Mexico. CHIHUAHUA, 100 km. S. of Guadalupe y Calvo, alt. 2,300 to 2,600 m., Aug., 1898 (*E. W. Nelson*, no. 4807). MICHOACAN, sandy fields, hills of Patzcuaro, Oct. 11, 1892 (*C. G. Pringle*, no. 4258). Originally collected by Humboldt & Bonpland near Patzcuaro.

* * Canescent-puberulent shrub: the firm leaves pale beneath: corolla pale blue or whitish.

128. S. SHANNONI, Donnell Smith, Bot. Gaz. xix. 256. — Southern Mexico and Central America. CHIAPAS, top of ridge back of Tonala, alt. 370 to 770 m., Aug. 10, 1895 (*E. W. Nelson*, no. 2898): GUATEMALA, Volcan Chingo, Dept. Jutiapa, alt. 925 m., Oct., 1892 (*W. C. Shannon* in exsicc. J. D. Smith, no. 3612); Chupadero, Dept. Santa Rosa, alt. 1,540 m., Oct., 1892 (*Heyde & Lux* in exsicc. J. D. Smith no. 4052). The Chiapas plant has broader leaves and bracts than those from Guatemala, but they undoubtedly belong together.

§ 6. LONGIFLORAE, Benth. Corolla from 2 to 12 cm. long, of various colors. (See note under § *Brachyanthae*.)

A. Luteae, Benth. Shrubs with axillary or racemose flowers: corolla yellow, ventricose below the throat.

* Flowers axillary, solitary: corolla 2 to 3 cm. long: leaves cordate-ovate, 2.5 cm. or less long, very rugose, canescent-tomentose beneath.

129. S. ASPERA, Mart. & Gal. l. c. 71; Benth. in DC. l. c. 327; Hemsl. l. c. 553; Briq. l. c. — Southern Mexico. PUEBLA, dry calcareous hills, Tehuacan, alt. 1,700 m. [the original station of Galeotti], Nov. 27, 1895 (*C. G. Pringle*, no. 6240): OAXACA, Jayacatlan, alt. 1,320 m., June 3, 1894, and Nov. 18, 1895 (*L. C. Smith*, nos. 17, 897); near Dominguillo, alt. 2,000 m., Oct. 3, 1894 (*E. W. Nelson*, no. 1587).

* * Flowers racemose.

+ Calyx invested with yellow or yellow and reddish tomentum: corolla yellow, red within, 2 to 3 cm. long: leaves rugose, canescent-tomentose beneath.

130. S. CHRYSANTHA, Mart. & Gal. l. c. 72; Benth. l. c. 326; Hemsl. l. c. 554; Briq. l. c. — Southern Mexico and Central America. GUERRERO, between Tlapa and Tlaliscatilla, alt. 1,200 to 1,880 m., Dec. 5, 1894 (*E. W. Nelson*, no. 2049); OAXACA, Monte Alban, alt. 1,850 m., Sept. 4, 1894 (*C. G. Pringle*, no. 4862), Oct. 11, 1895 (*L. C. Smith*, no. 950); Valley of Oaxaca, alt. 1,540 to 1,630 m., Sept. 25, 1894 (*E. W. Nelson*, no. 1244): CHIAPAS, without locality (*Ghiesbreght*, no.

765); between San Cristobal and Teopisca, alt. 2,060 to 2,600 m., Dec. 4, 1895, and between Hacienda Juncana and San Vincente, alt. 1,300 to 1,850 m., Dec. 12, 1895 (*E. W. Nelson*, nos. 3429, 3507).

+ + Calyx glandular-puberulent: corolla 3.5 to 4 cm. long: leaves cordate, acuminate, the lowest often 8 dm. long.

131. S. MADRENSIS, Seem. Bot. Herald, 327, t. 70; Hemsl. l. c. 560. — Described from the Sierra Madre of northwestern Mexico. Not seen.

B. Inflatae, Benth. Shrubs: calyx inflated-companulate, brightly colored: corolla scarlet; the tube subventricose. (Calyx and corolla by rare exception white.)

* Leaves ovate-lanceolate to oblong, cuneate or narrowed at base.

+ Calyx and corolla glabrous or merely puberulent: style glabrous.

132. S. SESSEI, Benth. Lab. 288, & in DC. l. c. 332; Hemsl. l. c. 565; Briq. l. c. 282. *S. Roezli*, Scheidw. Fl. des Serres, xiv. 31, t. 1407. *S. semperflorens*, La Llave in La Nat. vii. Apénd. 81, ex char. *S. fastuosa*, Sessé &. Moc. l. c. 7. *Rhodochlamys speciosa*, Schauer, Linnaea, xx. 707. — Southern Mexico. MORELOS, Cuernavaca, Nov. 14, 1865 (*Bourgeau*, no. 1238).

+ + Calyx and corolla glandular-pilose: style pilose.

133. S. WAGNERIANA, Polak. Linnaea, xli. 591. — Described from Costa Rica. Not seen.

* * Leaves ovate-lanceolate, cordate at base: stems viscid-hirsute.

134. S. ADGLUTINANS, Lag. Gen. & Spec. Nov. 2; Benth. l. c.; Hemsl. l. c. 552; Briq. l. c. — Described from "New Spain." Not seen.

* * * Leaves ovate, acuminate, rounded at base, white-tomentose beneath, 1 dm. or less in length: branches tomentose: shrub or small tree (1 to 6 m. high).

135. S. PUBESCENS, Benth. Lab. 723, & in DC. l. c.; Hemsl. l. c. 563; Briq. l. c. — Southern Mexico. MORELOS, near Cuernavaca, Oct. 27, 1895, and Nov. 9, 1895, calyx and corolla white (*C. G. Pringle*, nos. 7080, 7065): OAXACA, San Dionicio (*Andrieux*, no. 143); Jayacatlan, alt. 1,380 m., Sept. 10, 1894 (*L. C. Smith*, no. 170); Monte Alban, alt. 1,790 m., Oct. 4, 1894 (*C. G. Pringle*, no. 4960); near Oaxaca, alt. 1,600 to 1,930 m., Oct. 2, 1894, near Huajuapam, alt. 1,470 to 2,000 m., Nov. 19, 1894, and near Tlapancingo, alt. 1,850 to 2,460 m., Dec. 7, 1894 (*E. W. Nelson*, nos. 1972, 1521, 2091).

* * * * Leaves deltoid-ovate to orbicular, coriaceous, pubescent on the nerves beneath, 4 cm. or less long: branches slender, purplish, glabrous or glabrate.

136. S. REGLA, Cav. Ic. v. 33, t. 455; Benth. Lab. 288, & in DC. l. c., 333; Lindl. Bot. Reg. xxvii. t. 14; Hemsl. l. c. 564; Briq. l. c. *S. deltoidea*, Pers. Syn. i. 28. *S. negla*, Pers. l. c. as syn. *S. crenata*, Mart. & Gal. l. c. 74; Benth. l. c. 348; Hemsl. l. c. 555; Briq. Ann. Conserv. Jard. Bot. Genève, ii. 157. — Central and southern Mexico. Without locality (*Coulter*, no. 1099, *Gregg*, no. 340): COAHUILA, Lerios, July, 1880 (*Edw. Palmer*, no. 1079); shaded gulches of limestone hills, Carneros Pass, Sept. 1, 1889 (*C. G. Pringle*, no. 2384): DURANGO, Santiago Papasquiaro, 1896 (*Edw. Palmer*, no. 404), Aug. 7, 1898 (*E. W. Nelson*, no. 4663): SAN LUIS POTOSI, in woods, San Rafael, 1876 (*Schaffner*, no. 665); without locality, 1878 (*Parry & Palmer*, no. 741); San Luis Potosi, 1898 (*Edw. Palmer*, no. 726): AGUAS CALIENTES, by brooks (*Hartweg*, no. 165): GUANAJUATO, 1880 (*A. Dugès*): OAXACA, near Coixtlahuaca, alt. 2,150 to 2,300 m., Nov. 12, 1894 (*E. W. Nelson*, no. 1917).

C. Fulgentes, Benth. Shrubs, rarely herbs: calyx tubulose-campanulate: corolla scarlet or crimson; the tube straight, ventricose.

* Freely branching shrubs (rarely herbs) with leaves 1 to 4 cm. long.

+ Flowers axillary.

137. **S. disjuncta.** Branches ferrugineous-pubescent: leaves cordate, ovate, blunt or acuminate, 4 cm. or less long, rugose, crenulate, dark green and hispid above, canescent and pilose beneath, on slender petioles: verticels mostly 2-flowered, in the axils: pedicels 6 mm. or less in length, usually twisted: calyx pilose on the nerves, in anthesis 1.2 to 1.5 cm. long; the tube twice exceeding the ovate acuminate lobes; upper lip entire: corolla 3 to 4 cm. long, minutely pilose, the ventricose tube twice exceeding the calyx; galea and lip subequal: style bearded. — CHIAPAS, among rocks, Aug., Sept. (*Ghiesbreght*, nos. 76, 753); near San Cristobal, alt. 2,150 to 2,460 m., Sept. 18, 1895 (*E. W. Nelson*, no. 3166). A unique species.

+ + Flowers in terminal racemes.

++ Leaves ovate or broad oblong.

= Pubescence of branches and leaves simple.

a. Calyx hispidulous on the nerves.

1. Leaves glabrous or at least glabrate beneath.

138. S. GRAHAMI, Benth. Bot. Reg. xvi. t. 1370, & in DC. l. c. 335; Lodd. Bot. Cab. xviii. t. 1798; Ortgies, Gartenfl. vii. t. 242; Hemsl.

l. c. 557; Briq. in Engl. & Prantl l.c. *S. microphylla*, Gray, Proc. Am. Acad. xxi. 407, in part, not Benth. — Northern and central Mexico, not clearly separable from *S. microphylla*. CHIHUAHUA, 100 km. south of Guadalupe y Calvo, alt. 2,300 to 2,620 m., Aug., 1898 (*E. W. Nelson*, no. 4812[a]); Batopilas, alt. 1,690 to 2,000 m., Oct. 1898 (*E. A. Goldman*, no. 212): COAHUILA, hillside, Saltillo, May, 1898 (*Edw. Palmer*, no. 161): DURANGO, by stream, Durango, Nov. 1896 (*Edw. Palmer*, no. 844); near El Salto, July 12, 1898, and in the Sierra Madre, 25 km. north of Guanacevi, alt. 2,300 to 2,620 m., Aug. 17, 1898 (*E. W. Nelson*, nos. 4557, 4755): ZACATECAS, hills of Zacatecas, Oct. 26, 1888 (*C. G. Pringle*, no. 1764); in the Sierra Madre, Aug. 18, 1897, and near Plateado, Sept. 4, 1897 (*J. N. Rose*, nos. 2402, 2804): SAN LUIS POTOSI, in the mountains about San Luis Potosi, 1876 (*Schaffner*, no. 660), 1878 (*Parry & Palmer*, nos. 747, 748): VERA CRUZ, Mt. Orizaba, alt. 2,770 m., Aug. 8, 1891 (*Seaton*, no. 260): HIDALGO, Zimapan (*Coulter*, no. 1093): MEXICO, ledges and banks, Sierra de las Cruces, Oct. 23, 1892, and Serrania de Ajusco, alt. 2,770 m., May 23, 1898 (*C. G. Pringle*, nos. 4298, 7548).

2. Leaves pubescent beneath.

○ Shrubs.

+ Leaves mostly less than 2 cm. long.

139. S. MICROPHYLLA, HBK. l. c. 295. Leaves rounded at tip, slightly pubescent. — Benth. l. c.; Hemsl. l. c. 561; Gray, l. c., in part; Briq. l. c. — Central and southern Mexico. SAN LUIS POTOSI, San Miguelito, 1876 (*Schaffner*, no. 662); in market of San Luis Potosi, 1898 (*Edw. Palmer*, no. 640½): MEXICO, Valley of Mexico (*Schaffner*, no. 394); Toluca, Sept. 17, 1898 (*E. W. D. Holway*, no. 3136): OAXACA, Tehuacan, alt. 615 m., June 24, 1896 (*C. Conzatti*, no. 163).

Var. CANESCENS, Gray, l. c. Leaves and branchlets densely canescent-pubescent. — CHIHUAHUA, in shade of cliffs, hills near Chihuahua, Oct. 17, 1885 (*C. G. Pringle*, no. 637): ZACATECAS, hills near Zacatecas. Mar. 17, 1885 (*C. G. Pringle*, no. 239), alt. 2,460 m. Dec. 8, 1898 (*C. C. Deam*, no. 139).

Var. WISLIZENI, Gray, l. c. 408. Puberulent: leaves narrowed to acutish tips. — CHIHUAHUA, Sierra Madre west of Chihuahua (*Wislizenus*, no. 152); north of Batopilas, 1885 (*Edw. Palmer*, no. 379).

+ + Leaves larger.

× Leaves subsessile or short (3 mm.)-petioled.

140. S. TRICOLOR, Lemaire, Ill. Hort. iii. Misc. 71, t. 120, & Fl. des

Serres, xii. 109, t. 1237; Hemsl. l. c. iv. 81. — Introduced into cultivation from Mexico.

× × Leaves long-petioled.

╫ Corolla 2.5 to 2.75 cm. long.

☐ Leaves thin, hardly rugose, with subacuminate tips, pubescence rather sparse.

141. S. LEMMONI, Gray, Proc. Am. Acad. xx. 309, & Syn. Fl. l. c. 461; Hemsl. l. c. — Arizona and Chihuahua. CHIHUAHUA, Cañon de San Diego, Sept. 17, 1891 (*C. V. Hartman*, no. 738); foothills of Sierra Madre, near Colonia, Aug. 29, 1899 (*E. W. Nelson*, no. 6315).

☐ ☐ Leaves rugose, mostly rounded at tips: pubescence more abundant.

142. **S. neurepia.** Freely branching shrub: branches puberulent, the younger parts pilose or densely villous: leaves ovate or round-ovate, truncate or subcordate at base, coarsely crenate, thick, rather densely short-pubescent on both faces, 2.25 to 2.75 cm. long, twice exceeding the slender petioles: racemes 1 dm. or less in length; verticels mostly 2-flowered, all becoming a little remote: bracts ovate, ciliate, caducous: calyx glandular-puberulent, a little hispidulous on the nerves, tubular-campanulate, in anthesis 1 to 1.3 cm. long; the tube twice exceeding the ovate-acuminate lobes: upper lip entire: corolla-tube pale, glabrous, twice exceeding the calyx; the pilose galea hardly equalling the red lip: style bearded. — Central Mexico. SAN LUIS POTOSI, in woods near Morales, 1876 (*Schaffner*, no. 661); without locality, alt. 1,850 to 2,460 m., 1878 (*Parry* & *Palmer*, no. 754); in the market of San Luis Potosi, 1898 (*Edw. Palmer*, no. 640). Graham's no. 1096 without locality apparently belongs here, and Bourgeau's no. 856 from near Guadalupe, MEXICO, though with larger thinner leaves, may be an extreme form. This species, as well as *S. microphylla*, is sold in the market of San Luis Potosi as a *Mirto*, decoction from them being used to allay fever, headaches, and nervous irritations.

╫ ╫ Corolla 3.25 to 3.5 cm. long.

143. **S. Schaffneri.** Branches glandular-puberulent and slightly pilose: leaves thickish, rugose, deltoid-ovate, acuminate, rounded-truncate at base, puberulent on both faces, 2.5 to 4 cm. long, 1.5 to 3 cm. wide, irregularly crenulate, on slender petioles 1 to 2.5 cm. long: racemes becoming 1 to 1.5 dm. long; verticels mostly 4-flowered, all becoming remote, the lowest 2.5 cm. apart: bracts 5 mm. long, ovate, long-acuminate: pedicels 3 to 5 mm. long: calyx tubular-campanulate and minutely hispidulous, in anthesis, 1 to 1.2 cm. long; the tube twice

exceeding the lobes; upper lip oblong-ovate, entire, blunt, lower with two acuminate narrower lobes: corolla-tube glabrous, twice exceeding the calyx; galea slightly pilose at tip, shorter than the lip. — SAN LUIS POTOSI, in the mountains near Morales, 1876 (*Schaffner*, no. 667), called "mirto grande." Habitally this plant suggests *S. fulgens*, var. *Boucheana*, Benth., but it is readily distinguished by its less pubescent leaves, shorter calyx and slightly pilose galea.

○ ○ Pubescent herb with ovate obtuse leaves canescent beneath.

144. S. OBTUSA, Mart. & Gal. l. c. 72; Benth. in DC. l. c. 334; Van Houtte, Fl. des Serres, xiv. t. 1412 (?); Hemsl. l. c. ii. 562. — Described from OAXACA. Various plants are cultivated under this name, but the figure above cited perhaps best represents the species.

b. Calyx glabrous or barely puberulent at base.

145. **S. oresbia.** Small shrub, 2 to 3 dm. high: branches purplish, puberulent in lines or glabrate: branchlets short, leafy mostly at the tip: leaves firm, ovate, acute at each end, appressed-serrate, glabrate, 1 to 2.5 cm. long: racemes 1 dm. or less in length; verticels 2–4-flowered: bracts firm, ovate, acuminate, 1 cm. or less long, persistent: pedicels 3 to 7 mm. long, puberulent: calyx purple-tinged, in anthesis 1 to 1.2 cm. long, puberulent within; the tube thrice exceeding the broad ovate mucronate-acuminate lobes: corolla 2 cm. long; the glabrous strongly ventricose tube one half longer than the calyx; the pilose galea hardly equalling the lip: style glabrous. — SAN LUIS POTOSI, in the mountains, San Rafael, 1876 (*Schaffner*, no. 666); without locality, alt. 1,850 to 2,460 m., 1878 (*Parry & Palmer*, no. 740).

= = Pubescence of branches and leaves stellate.

146. **S. oaxacana.** Very branching shrub: the bark pale gray, the young branches and branchlets white with stellate tomentum: leaves ovate, truncate or cordate at base, 1 cm. or less in length, pale green and strongly rugose above, white-tomentose beneath, crenate, one-half longer than the tomentose petioles: racemes 6 cm. or less long; the verticels mostly 2-flowered, 1 to 1.5 cm. apart: bracts ovate-lanceolate, caducous: pedicels 3 to 6 mm. long, glandular-pilose: calyx open-campanulate, glandular-pilose, in anthesis 8 to 10 mm., in fruit becoming 1.3 to 1.5 cm. long: the upper lip broad-ovate, mucronate, somewhat bidentate, the lower lip with 2 ovate-lanceolate acuminate lobes: corolla somewhat glandular-pilose; the strongly ventricose tube twice exceeding the calyx; the galea and lip subequal: style bearded. — OAXACA, La Hoya Cañon,

alt. 1,380 m., Nov. 2, 1894 (*C. G. Pringle*, no. 5654). Resembling *S. aspera*, Mart. & Gal., from which it differs in its short terminal racemes of red flowers.

↔ ↔ Leaves from narrow oblong to linear-oblanceolate.

147. S. GREGGII, Gray, Proc. Am. Acad. viii. 369, & Syn. Fl. l. c 368; Hemsl. l. c. 557, & iv. 81; Hook. Bot. Mag. t. 6812. *S. microphylla*, Torr. Bot. Mex. Bound. 131, not HBK. — Texas to Durango. COAHUILA, cañon above Palomas, 1848–49 (*Gregg*, no. 335); high dry ridge, battlefield of Buena Vista (*Gregg*); Saltillo, 1878 (*Parry*, no. 26); Lerios, July, 1880, and near Saltillo, May, 1898 (*Edw. Palmer*, nos. 1071, 153): DURANGO, shady hillsides and river-banks, Santiago Papasquiaro, Aug., 1896 (*Edw. Palmer*, no. 417).

* * Branching or subsimple shrubs or half-shrubs or tall herbs, leafy nearly or quite to the inflorescence: leaves larger, only the smallest 4 cm. long.

← Leaves pubescent beneath.

↔ Calyx-lobes with long setaceous-acuminate tips: corolla 2.5 to 4 cm. long: branches densely tomentose, viscid above.

= Leaves densely tomentose beneath, minutely so above.

148. S. LINDENII, Benth. in DC. l. c. 333; Hemsl. l. c. ii. 560; Briq. l. c. — Southern Mexico and adjacent Central America. OAXACA, between Pluma and San Miguel Suchistepec, alt. 2,460 to 3,070 m., March 21, 1895 (*E. W. Nelson*, no. 2508): CHIAPAS, without locality (*Ghiesbreght*, nos. 122, 755): GUATEMALA, Volcan de Agua, Dept. Zacatepéquez, alt. 2,770 m., Apr., 1890 (*J. D. Smith*, no. 2169).

= = Leaves greener, thinly pubescent beneath, becoming glabrate above.

149. S. RECTIFLORA, Vis. Sem. Hort. Pat. 1839, ex ejusd. Ort. Bot. Pad. 145; Benth. l. c. 334; Hemsl. l. c. 564, excl. syn. — South-central Mexico. GUANAJUATO, rocky mountain-slopes, 1880, 1894 (*A. Dugès*).

↔ ↔ Calyx-lobes blunt or mucronate or merely short-acuminate.

= Corolla 4 to 6 cm. long.

a. Leaves densely white-tomentose beneath, finely crenate-serrate, and with sharp-acuminate tips: calyx glandular-puberulent.

150. S. FULGENS, Cav. Leaves cordate-ovate. — Ic. i. 15, t. 23; Sweet, Brit. Fl. Gard. ser. 2, i. t. 59; Lindl. Bot. Reg. xvi. t. 1356; Benth. l. c. 333; Hemsl. l. c. 556; Briq. l. c. *S. cardinalis*, HBK. l. c. 300, t. 152. *S. grandiflora*, Sessé & Moc. l. c. 7. — Central Mexico. ZACATECAS, on the Sierra de los Morones, near Plateado, Sept. 1, 1897 (*J. N. Rose*, no. 2743): JALISCO, between San Sebastian and the sum-

mit of Mt. Bufa de Mascota, alt. 2,150 to 2,300 m., March 20, 1897 (*E. W. Nelson*, no. 4093): MICHOACAN, Tlalpujahua (*Graham*): MEXICO, Toluca (*Andrieux*, no. 144); Désierto Viejo, Sept. 7, 1865, and San Nicolas, Oct. 26, 1865 (*Bourgeau*, nos. 853, 1106); Valley of Mexico (*Schaffner*, no. 396); cool forests, Sierra de las Cruces, alt. 3,230 m., Aug., 1892 (*C. G. Pringle*, no. 4227); Amecameca, Feb. 3, 1893 (*E. W. Nelson*, no. 6); foothills, Mt. Ixtaccihautl, Jan. 5, 1899 (*C. C. Deam*, no. 124): MORELOS, Serrania de Ajusco, alt. 2,460 m., May 26, 1898 (*C. G. Pringle*, no. 6862).

Var. BOUCHEANA, Benth. l. c. 334. Leaves narrowly deltoid-ovate, truncate or subcordate at base. — *S. Boucheana*, Kunth, Ind. Sem. Hort. Berol. 1845. — MICHOACAN, Tlalpujahua (*Graham*): PUEBLA, calcareous hills near Tehuacan, Aug. 30, 1897 (*C. G. Pringle*, no. 7449).

b. Leaves merely pilose on the nerves beneath, coarsely crenate, and with blunt tips: calyx not at all or very minutely glandular-puberulent.

151. **S. orizabensis.** Branches short-pilose with recurved hairs, minutely glandular above: leaves ovate, thin, minutely pilose above, 4 to 8 cm. long; the base subcordate with a short acumination at the junction with the slender retrorse-pilose petiole: raceme 1 dm. or so long; verticels 4–10-flowered, all remote, the lowest 4 to 5 cm. apart: bracts ovate-lanceolate, acuminate: pedicels 3 to 5 mm. long, sordid-viscid: calyx in anthesis 1.5 to 1.75 cm. long, slightly pilose on the nerves; the tube nearly twice exceeding the ovate bluntish lobes; upper lip entire: corolla-tube glabrate, twice exceeding the calyx; galea, long-bearded, equalling the lip: style somewhat bearded. — VERA CRUZ, Mt. Orizaba (*Botteri*, no. 1168).

= = Corolla 2.5 to 2.75 cm. long.

152. **S. adenophora.** Shrub ("sarmentose" according to Smith) with brown bark; the branches glandular-pilose: leaves cordate-ovate, acuminate (rarely blunt), crenate-serrate, green and sparingly pubescent above, more or less white tomentose beneath, 4 to 10 cm. long, on slender petioles 3 cm. or less in length: racemes 3 dm. or less in length; the rhachis very glandular-hairy; verticels 6–20-flowered, all remote, the lowest 2 to 3 cm. apart: bracts ovate, glandular, caducous: pedicels 6mm. or less in length, glandular: calyx campanulate, very glandular, in anthesis 8 to 10 mm. long, the tube twice exceeding the broad ovate mucronate or short-acuminate lobes; upper lip entire: corolla glandular-pilose, the tube once and a half longer than the calyx; galea and lip subequal: style bearded. — OAXACA, Jayacatlan, alt. 1,230 m., Sept. 11,

1894, and Nov. 17, 1895 (*L. C. Smith*, nos. 168, 875); between Tlapancingo and Tlalixtaquilla, GUERRO, alt. 1,600 to 1,230 m., Dec. 9, 1895 (*E. W. Nelson*, no. 2093, in part); El Parián-Etla, alt. 1,200 m., Nov., 1898 (*V. González & C. Conzatti*, no. 900).

= = = Related to the above, but not identified, is

153. S. LINEATA, Benth. Lab. 724, with the branches pubescent in lines, obtuse leaves slightly pubescent, truncate at base, and with the flowers somewhat smaller than in *S. fulgens*, in 4–6-flowered verticels.

+ + Leaves glabrous beneath.

++ Calyx herbaceous; the tube becoming corrugated; the 3 acuminate lobes large and subequal, long-ciliate on the margins.

154. S. PRINGLEI, Robinson & Greenman, Proc. Am. Acad. xxix. 391. — JALISCO, under cliffs, barranca of Tequila, Oct. 2, 1893 (*C. G. Pringle*, no. 4564).

++ ++ Calyx less herbaceous; the tube sub-inflated, not corrugated; the lobes unequal.

= Leaves cuneate at base.

155. S. INVOLUCRATA, Cav. Ic. ii. 3, t. 105; Lindl. Bot. Reg. xiv. t. 1205; Bot. Mag. t. 2872; Benth. l. c. 333; Hemsl. l. c. 558, in part; Briq. l. c. *S. laevigata*, HBK. l. c. 295, t. 147. *S. Tonduzii*, Briq. Ann. Conserv. Jard. Bot. Genève, ii. 157. — Southern Mexico and Central America. GUATEMALA, Coban, Dept. Alta Verapaz, alt. 1,320 m., Nov. 1886 (*H. von Tuerckheim* in exsicc. J. D. Smith, no. 345); Jumaytepeque, Dept. Santa Rosa, alt. 1,850 m., Jan., 1893 (*Heyde & Lux* in exsicc. J. D. Smith, no. 4397).

= = Leaves cordate-ovate.

a. Calyx in anthesis 0.6 to 1 cm. long.

156. S. PULCHELLA, DC. Cat. Hort. Monsp. 142; Colla, Hort. Ripul. 125, t. 16; Benth. l. c. 334; Hemsl. l. c. 563; Briq. in Engl. & Prantl, l. c. — Southern Mexico and Central America. CHIAPAS, without locality (*Ghiesbreght*, nos. 71, 758); near San Cristobal, alt. 2,150 to 2,460 m., Sept. 18, 1895, and between San Cristobal and Teopisca, alt. 2,060 to 2,610 m., Dec. 4, 1895 (*E. W. Nelson*, nos. 3171, 3427): GUATEMALA, Purulá, Dept. Baja Verapaz, alt. 1,540 m., Apr. 1887 (*H. von Tuerckheim* in exsicc. J. D. Smith, no. 1194).

b. Calyx in anthesis 1.5 to 2 cm. long.

157. **S. puberula.** Stem herbaceous, simple, 8 dm. high, from a woody base, minutely cinereous-puberulent: leaves 7 to 10 cm. long,

acuminate, appressed-serrate quite to the base, dull and minutely puberulous above, pale and glabrous beneath, on slender puberulent petioles 4.5 cm. or less in length: raceme simple, 1.3 dm. long; the rhachis and pedicels glandular and sparingly pilose; verticels 6–10-flowered, all remote, the lowest 2.5 cm. apart: bracts caducous (not seen): calyx tubular-campanulate, slightly pilose on the nerves; the lobes setaceous-acuminate, the upper lip twice exceeding the 2-lobed lower one, and twice exceeded by the tube: corolla 3 to 4 cm. long, the moderately ventricose glabrous tube twice as long as the calyx; the pilose galea equalling the lip: style bearded. — *S. involucrata*, Hemsl. l. c. 558, in part, not Cav. — SAN LUIS POTOSI, alt. 1,850 to 2,460 m., 1878 (*Parry & Palmer*, no. 755).

* * * Stoloniferous herb; the subdeltoid or cordiform leaves confined chiefly to the lower half: peduncle elongated, simple; verticels 2–6-flowered, remote: corolla 5 cm. long.

158. S. STOLONIFERA, Benth. Pl. Hartw. 70, & in DC. l. c. 333; Hemsl. 565; Briq. l. c. — OAXACA, Sierra de San Felipe, alt. 2,300 to 3,080 m., June 23, 1894 (*C. G. Pringle*, no. 4705, *E. W. Nelson*, no. 1183); Telixtlahuaca, alt. 2,300 m., July 27, 1895 (*L. C. Smith*, no. 477).

D. Cyaneae, Benth. Calyx tubulose-campanulate: corolla blue violet or rose, straight; the tube ventricose.

* Corolla rose or rose-purple.

+ Leaves hispid or pilose beneath.

++ Leaves rounded-cuneate at base: corolla 1.5 to 1.8 cm. long.

159. S. PURPURASCENS, Mart. & Gal. l. c. 69; Benth. in DC. l. c. 335; Hemsl. l. c. 564; Briq. l. c. 283. — Described from Mt. Orizaba, VERA CRUZ. Not seen.

++ ++ Leaves cordate at base.

= Verticels 6-flowered: calyx 1.3 cm. long: corolla 3 cm. long.

160. S. IODOCHROA, Briq. Ann. Conserv. Jard. Bot. Genève, ii. 161. — Described from COSTA RICA. Not seen.

= = Verticels 10–30-flowered: mature calyx 8 mm. long: corolla 1.5 cm. long.

161. **S. irazuensis.** Tall and freely branching, the stem purple, slightly crisp-pilose in lines, or glabrate; the branchlets glandular-pilose: internodes long (1 dm.): leaves cordate-ovate, acuminate, serrate, the

larger 5 to 6 cm. long, green and glabrate above, pale and appressed-pilose on the nerves beneath: racemes elongated, 3 to 4 dm. or less long; verticels all remote: pedicels becoming 6 to 8 mm. long, glandular-pilose: calyx puberulent, short pilose on the nerves; the upper lip ovate, short-acuminate, one half as long as the tube, the lower lip with 2 lance-ovate setaceous-acuminate lobes: corolla-tube once and a half longer than the calyx; the pilose galea shorter than the lip: style bearded. — *S. tiliaefolia*, Donnell Smith, l. c. v. 71, in part, not Vahl. — COSTA RICA, Volcan Irazu, Prov. Cartago, alt. 3,000 m., Mar., 1894 (*J. Donnell Smith*, no. 4920). Near the last species, but with much smaller flowers, in denser verticels.

+ + Leaves glabrous or merely puberulent beneath, rounded or subcordate at base: corolla 1.3 to 2.5 cm. long.

162. S. MARTENSII, Gal. Bull. Acad. Brux. l. c. 77; Benth. l. c.; Hemsl. l. c. 560; Briq. l. c., & in Engl. & Prantl, l. c. *S. membranacea*, var. *villosa*, Benth. Lab. 720. *S. villosula*, Benth. in DC. l. c.; Briq. Ann. Conserv. Jard. Bot. Genève, ii. 160. — Southern Mexico. OAXACA, Sierra de San Felipe, alt. 3,170 m., Aug. 8, 1894 (*C. G. Pringle*, no. 4772), alt. 2,920 to 3,380 m., 1894 (*E. W. Nelson*, no. 1100), alt. 3,000 m., Nov. 14, 1897 (*C. Conzatti* and *V. González*, no. 539): CHIAPAS, among the mountains (*Ghiesbreght*, no. 742). Ghiesbreght's plant with rounded, not subcordate leaf-bases and corolla only 1.3 cm. long, probably represents *S. villosula* which Briquet maintains at least as a subspecies.

* * Corolla blue or violet.

+ Leaves cuneate or narrowed at base.

++ Leaves lanceolate or oblong-lanceolate.

= Leaves oblong-lanceolate, acuminate, crenate-serrate, more or less pubescent beneath: corolla-tube and galea white; lip dark blue.

163. S. ALBO-CAERULEA, Linden, Belg. Hort. vii. 199, & Gartenfl. vii. 55, 97, t. 221; Hemsl. l. c. iv. 80. — South-central Mexico. MORELOS, wet mountain cañon above Cuernavaca, alt. 2,000 m., May 15, 1898, Feb. 15, 1899 (*C. G. Pringle*, nos. 7615, 8020), distributed under an unpublished manuscript name. Originally from MICHOACAN.

= = Leaves elliptic-lanceolate, caudate-acuminate, sharply dentate-serrate, glabrous beneath: corolla violet-purple.

164. S. PANSAMALENSIS, Donnell Smith, Bot. Gaz. xxiii. 249. — GUATEMALA, Pansamalá, Dept. Alta Verapaz, alt. 1,230 m., June, 1886 (*H. von Tuerckheim* in exsicc. J. D. Smith, no. 933).

++ ++ Leaves ovate or ovate-oblong, crenate-serrate: corolla deep blue.

= Leaves thin, glabrous beneath: raceme slender, lax; the remote verticels 2–8-flowered: lower lip of calyx entire.

165. S. PHAENOSTEMMA, Donnell Smith, l. c. 13. — GUATEMALA, between Rodes and Malacate, Dept. San Márcos, alt. 430 to 1,080 m., Jan. 31, 1896 (*E. W. Nelson*, no. 3736).

= = Leaves tomentulose beneath: raceme rather dense, the verticels many-flowered: lower lip of calyx 2-lobed.

a. Bracts ovate-acuminate, herbaceous, cinereous-pubescent, 8 mm. or less in length: corolla-tube glabrous; galea short-pilose.

166. S. MEXICANA, L. Racemes becoming lax, 4 dm. or less long: calyx cinereous-pubescent on the nerves, in anthesis 1.5 cm. long. — Sp. 23; Cav. Ic. i. 16, t. 25; Benth. in DC. l. c. 337; Hemsl. l. c. ii. 561; Briq. in Engl. & Prantl, l. c. *S. melissifolia*, Desf. Cat. Hort. Par. Ed. 3, 94. *Jungia altissima*, Moench, Meth. 379. *Sclarea mexicana*, Dill. Hort. Elth. 339, t. 254, f. 330. — Central Mexico. Without locality (*Coulter*, no. 1100): GUANAJUATO, 1880 (A. Dugès): ZACATECAS, near Monte Escobedo, Apr. 26, 1897 (*J. N. Rose*, no. 2635): MEXICO, Tokobaya, Aug. 10, 1865 (*Bilimek*, no. 308); Valley of Mexico, July 21, 1865, and Aug. 1, 1865 (*Bourgeau*, nos. 993, 619), Sept. 19, 1889 (*C. G. Pringle*, no. 2824); Rio Hondo Cañon, 1890 (*C. G. Pringle*, no. 3157).

Var. MAJOR, Benth. l. c. Similar but with glabrate calyx. — *S. papilionacea*, Cav. Ic. iv. 9, t. 319. *S. nitidifolia*, Ort. Dec. 53. — Without locality (*Coulter*, no. 1101): MEXICO, near City of Mexico (*Graham*).

Var. MINOR, Benth. l. c. Racemes shorter: calyx pubescent, in anthesis 0.9 to 1.3 cm. long. — *Ocimum micranthum*, Wats. Proc. Am. Acad. xxi. 435, not Willd. — Extending further north than the species. CHIHUAHUA, Frayles, 1885 (*Edw. Palmer* no. 290): near BATOPILAS, alt. 1,690 to 2,000 m., Oct. 4–5, 1898 (*E. A. Goldman*, no. 205): SAN LUIS POTOSI, near Morales, 1876 (*Schaffner*, no. 677); without locality, 1878 (*Parry & Palmer*, nos. 757, 758): ZACATECAS, Plateado, Sept. 3, 1897 (*J. N. Rose*, no. 3638): MEXICO, Toluca (*Andrieux*, no. 148); San Angel, May 31, 1866 (*Bourgeau*, no. 126); Amecameca, Jan. 5, 1899 (*C. C. Deam*); Tizapan, alt. 2,310 m., Sept. 23, 1899 (*C. G. Pringle*, no. 7936).

b. Bracts oblong-ovate, acuminate, membranaceous, veiny, glabrate, 2 cm. long: corolla long-pilose.

167. **S. lupulina.** Stems cinereous-puberulent: leaves ovate or

rhombic-ovate, acuminate at tip, rounded-cuneate at base, about 1 dm. long, appressed-serrate, green and sparingly puberulent above, canescent-puberulent beneath, on slender canescent petioles 8 cm. or less in length: racemes in bud resembling the fruit of the hop (*Humulus lupulus*); the membranaceous veiny bracts caducous: racemes becoming 1.5 dm. long; the verticels 10–many-flowered, the lowest a little remote: pedicels 1 cm. or less long, puberulent: calyx hispidulous at base, glabrate above, violet-tinged, in anthesis 1.3 to 1.7 cm. long; the tube 3 or 4 times exceeding the lobes; upper lip broad-ovate, short-acuminate, entire, lower with 2 narrower acuminate lobes: corolla 3 to 4.5 cm. long, the tube once to once and a half longer than the calyx; galea slightly exceeding the lip: style exserted, densely bearded. — OAXACA, mountains of San Juan del Estado, alt. 2,310 m., Sept. 11, 1894 (*L. C. Smith*, no. 167); near Tlapancingo, alt. 1,850 to 2,460 m., Dec. 7, 1894 (*E. W. Nelson*, no. 2068).

+ + Leaves round round-truncate or cordate at base.

++ Leaves glabrous beneath.

= Bracts somewhat persistent, lasting through anthesis: calyx in anthesis 2 cm. long: corolla 5 cm. long, violet.

168. S. IANTHINA, Otto & Dietr. Allgem. Gartenz. xv. 362; Decaisne, Fl. des Serres, ix. 73, t. 884. — Habitat unknown, supposed to come from Mexico or Peru.

= = Bracts caducous.

a. Calyx villous.

1. Corolla violet, 3.75 to 5 cm. long, three or four times exceeding the calyx: leaves thin, long-acuminate, glandular-punctate.

169. S. RECURVA, Benth. in DC. l. c. 336; Hemsl. l. c. 564; Briq. l. c. — CHIAPAS, very rare in the forests (*Ghiesbreght*, nos. 24, 756). Originally collected in the Sierra de San Pedro Nolesco.

2. Corolla twice as long as the calyx.

170. S. CONCOLOR, Lamb. in Benth. Lab. 297; Benth. in DC. l. c.; Hemsl. l. c. 555. — Described from "Mexico."

b. Calyx glabrate, with acuminate-attenuate lobes: corolla 2.5 cm. long, thrice exceeding the calyx.

171. S. GLABRATA, HBK. l. c. 299; Benth. l. c.; Hemsl. l. c. 556; Briq. l c. — Described from Venezuela, but reported from "Mexico" by Benth. l. c.

↔ ↔ Leaves pubescent beneath.

= Stem glandular-setulose : leaves setulose-hispid above, coarsely and irregularly serrate : calyx setulose-hispid : corolla barely 2 cm. long.

172. S. BISERRATA, Mart. & Gal. l. c. 66 ; Benth. l. c. 335 ; Hemsl. l. c. 553 ; Briq. l. c. — CHIAPAS (*Ghiesbreght*, no. 763). Described from Mt. Orizaba.

= = Stem villous above, glabrate below : leaves minutely pubescent above, finely and regularly crenate-serrate : calyx pilose : corolla 2.5 to 3 cm. long.

173. S. CYANEA, Benth. Lab. 296, & in DC. l. c. 336 ; Hemsl. l. c. 555. *S. cyaniflora*, Dietr. in Otto & Dietr. l. c. i. 301. *S. cyanifera*, Otto in Benth. l. c. as syn. — Central Mexico. MEXICO, Désierto Viejo, Sept. 7, 1865 (*Bourgeau*, no. 837).

E. Tubiflorae, Benth. Shrubs (rarely herbs) with tubulose-campanulate calyx : corolla scarlet crimson flesh-colored or purple, rarely blue-violet ; the tube straight or curved, cylindric or ampliate (not ventricose) above.

* Leaves cuneate or narrowed at base. (Forms of *S. cinnabarina*, *elegans*, and *nervata* may be looked for here.)

← Leaves pubescent beneath, corolla rose-purple.

↔ Leaves softly canescent-tomentose or cinereous-pilose beneath.

= Calyx minutely pilose, in anthesis 9 to 10 mm. long ; the tube once and a half exceeding the ovate-lanceolate acuminate lobes : corolla 2.5 to 4 cm. long.

174. S. CURVIFLORA, Benth. Lab. 284, & in DC. l. c. 340 ; Hemsl. l. c. 555 ; Briq. l. c. — HIDALGO, Zimapan (*Coulter*, nos. 1088, 1089, 1090) : MICHOACAN, Tlalpujahua (*Graham*).

= = Calyx hispidulous : corolla 1.5 to 1.8 cm. long.

175. **S. chiapensis.** Fruticose (?), the tall simple branches puberulent below, pilose-hispid above : leaves thick, ovate or oblong-ovate, appressed-serrate, acuminate at tip, subcuneate at base, 5 to 12 cm. long, green and minutely pilose above, canescent and subvelutinous beneath, on puberulent petioles 3.5 cm. or less in length : raceme 3 to 4 dm. or less long ; the verticels 6–10-flowered, all becoming remote, the lowest 3 to 4 cm. apart : bracts oblong-ovate, acuminate, short-pubescent, 1.5 cm. or less in length, caducous : pedicels becoming 5 mm. long : calyx in anthesis 7 to 8 mm. long ; the tube nearly twice exceeding the ovate-lanceolote acuminate lobes : corolla-tube about twice exceeding the calyx ; the densely villous galea about equalling the lip : style bearded. — CHIAPAS, without locality (*Ghiesbreght*, nos. 57, 761) ; near San Cristobal, alt. 2,150 to 2,460 m., Sept. 18, 1895 (*E. W. Nelson*, no. 3201).

= = = Calyx long-pilose : corolla 2.5 to 3 cm. long.

176. **S. venosa.** Herbaceous, with erect branches; stem hollow, strongly quadrangular, pilose: leaves thin, ovate or rhombic ovate, crenulate-serrate, short-acuminate at tip, rounded-cuneate at base, 3.5 to 8 cm. long, green and short-pilose above, conspicuously veiny and cinereous-pilose beneath; the upper most often sessile, the others on slender pilose petioles 2.5 cm. or less in length: racemes 0.6 to 1.2 dm. long; the rhachis white-pilose, densely so in the axils; verticels 2–8-flowered, all remote, the lowest 1 to 2 cm. apart: pedicels filiform, white-pilose, becoming 5 mm. long: calyx in anthesis 7 mm. long; the tube thrice exceeding the ovate short-acuminate lobes: corolla villous; the tube twice longer than the calyx; the galea 5 mm. long, arcuate-cucullate above the short lip: style bearded. — CHIAPAS, on plains, Aug. (*Ghiesbreght*, no. 749); near San Cristobal, alt. 2,150 to 2,460 m., Sept. 18, 1895 (*E. W. Nelson*, no. 3138).

++ ++ Shrub with oblong-lanceolate leaves green and sparingly pilose beneath: rhachis and calyx glandular-pilose; the upper calyx-lip 3-dentate, the middle tooth filiform-appendiculate: corolla 1.5 cm. long.

177. S. ANTENNIFERA, Briq. Ann. Conserv. Jard. Bot. Genève, ii. 168. — Described from CHIAPAS. Not seen.

+ + Leaves glabrous beneath or merely puberulent on the nerves.

++ Leaves ovate: corolla scarlet or carmine.

178. S. TUBIFERA, Cav. Ic. i. 16, t. 25; Lindl. Bot. Reg. xxvii. t. 44; Benth. l. c. 341; Hemsl. l. c. 566; Briq. in Engl. & Prantl. l. c. *S. longiflora*, Willd. Spec. i. 141. — Described from Mexico. Not seen.

++ ++ Leaves oblong, 2 cm. long: corolla blue-violet.

179. S. ZACUALPENSIS, Briq. Ann. Conserv. Jard. Bot. Genève, ii. 166. — Described from CHIAPAS. Not seen.

++ ++ ++ Leaves oblong-lanceolate, 1.5 to 2 dm. long.

= Verticels 2-flowered: calyx 1.7 cm. long: corolla crimson-violet.

180. S. BELLA, Briq. l. c. 169. — Described from COSTA RICA. Not seen.

= = Verticels 4–6-flowered: calyx in anthesis 9 mm. long: corolla vermilion.

181. **S. miniata.** Glabrate shrub: branches very slender, deeply furrowed: leaves thin, minutely puberulent on the nerves above, otherwise glabrous, long-acuminate at both ends, sharply serrate; petioles 1 to 2 cm. long: peduncle 1 dm. long; raceme slightly longer; verticels

remote, the lowest 3 to 4 cm. apart: pedicels puberulent, 3 mm. long: calyx minutely puberulent or glabrate; the tube thrice longer than the lips; upper lip broad-ovate, blunt or short-mucronate, lower with two short incurved subulate teeth: corolla 3 to 3.25 cm. long, slightly curved, short-pilose; the tube twice longer than the calyx; the galea and lip subequal: style glabrous or very slightly bearded. — CHIAPAS, in the forests, flowering in June (*Ghiesbreght*, no. 760).

* * Leaves rounded or cordate at base. (*S. curviflora* may be looked for here.)

+ Leaves rounded or rounded-truncate at base, not definitely cordate.

++ Leaves lanceolate, 1 to 1.5 dm. long.

182. **S. perlonga.** Shrub with pilose-hispid branches: leaves thick, with long-attenuate tips, crenulate-serrate, rugose and covered with short dense plush-like indumentum above, canescent-velutinous beneath, on canescent petioles 2 cm. or less long: racemes 1 to 2 dm. long; verticels 2–8-flowered, all remote; pedicels and rhachis sordid glandular-pilose: calyx purplish, glandular, pilose-hispidulous, in anthesis 1.3 cm. long, the tube twice exceeding the blunt ovate entire lips: corolla vermilion, 3 cm. long, the slightly ventricose tube twice exceeding the calyx; the minutely pilose lips subequal: style slightly bearded. — GUERRERO, northeast slope of Sierra Madre, near Chilpancingo, alt. 2,150 to 2,620 m., Dec. 24, 1894 (*E. W. Nelson*, no. 2186). Further material may show this to belong with the *Fulgentes*.

++ ++ Leaves ovate or ovate-lanceolate, shorter.

= Corolla purple rose-purple or flesh-colored.

a. Leaves glabrous or only minutely puberulent beneath, not pilose (except slightly so in var. of *S. purpurea*).

1. Branches canescent-velutinous: verticels 2-flowered.

183. S. GRACILIFLORA, Mart. & Gal. l. c. 75; Benth. l. c. 342; Hemsl. l. c. 557. — Described from Zacuapan. Not seen.

2. Branches slightly pilose, puberulent or glabrous: verticels several–many-flowered.

○ A pair of glands generally present at the base of the petiole: corolla slender, puberulent, 2 to 2.75 cm. long.

184. S. PURPUREA, Cav. Minutely puberulent or glabrous. — Ic. ii. 52, t. 166; Jacq. Hort. Schoenb. iii. 2, t. 253; Benth. l. c. 341; Hemsl. l. c. 564; Briq. l. c. *S. affinis*, Cham. & Schl. Linnaea, v. 99; Benth. l. c.; Hemsl. l. c. 552; Briq. l. c. — Southern Mexico and Central America. JALISCO, Bolaños (*Hartweg*, no. 161): MORELOS, Cuernavaca,

Nov. 14, 1865 (*Bourgeau*, no. 1244): VERA CRUZ, region of Orizaba, without date (*Botteri*, no. 576), Oct. 2, 1866 (*Bourgeau*, no. 3162), Feb.–May, 1885 (*A. Gray*), March 10, 1894 (*E. W. Nelson*, no. 189): JALAPA, alt. 1,230 to 1,380 m., Jan., 1894 (*C. L. Smith*, no. 1781): OAXACA, near Oaxaca, alt. 1,600 to 2,090 m., Oct. 2, 1894, and near Tlapancingo, alt. 1,850 to 2,460 m., Dec. 7, 1894 (*E. W. Nelson*, nos. 1501, 2087); Sierra de San Felipe, alt. 2,000 m., Sept. 23, 1895 (*C. Conzatti*, no. 717): CHIAPAS, without locality (*Ghiesbreght*, no. 128); near Yajalon, Nov. 21, 1895, between San Cristobal and Teopisca, alt. 2,060 to 2,610 m., Dec. 4, 1895, and valley of Comitan, alt. 1,780 to 2,000 m., Dec. 8, 1895 (*E. W. Nelson*, nos. 3401, 3478, 3484): GUATEMALA, Coban, Dept. Alta Verapaz, alt. 1,320 m., Nov., 1886 (*H. von Tuerckheim* in exsicc. J. D. Smith, no. 500); Castillas, Dept. Santa Rosa, alt. 1,230 m., Jan., 1893 (*Heyde & Lux* in exsicc. J. D. Smith, no. 4398): COSTA RICA (*Oersted*).

Var. PUBENS, Gray. Stems and leaves slightly pilose. — Proc. Am. Acad. xxii. 446. — JALISCO, deep ravines and shaded hillsides, Rio Blanco, Oct., 1886 (*Edw. Palmer*, no. 662); near Guadalajara, Oct. 2, 1889 (*C. G. Pringle*, no. 2458).

○ ○ **No glands at base of petiole: corolla hardly slender, villous, 2.5 to 4 cm. long.**

185. S. LITTAE, Vis. Ill. Piant. Nuov. Ort. Padov. 15; Benth. l. c.; Hemsl. l. c. 560; Briq. l. c. — OAXACA, near Oaxaca, alt. 2,300 to 2,930 m., Sept., 1894 (*E. W. Nelson*, no. 1342); Sierra de Clavellinas, alt. 2,770 m., Oct. 18, 1894 (*C. G. Pringle*, no. 4991); Rancho de Caciques, alt. 1,540 m., Sept. 5, 1895 (*L. C. Smith*, no. 698).

_b._ Leaves more or less pilose or tomentose beneath.

1. Pubescence simple.

○ Leaves merely pilose beneath.

+ Leaves broad-ovate: corolla deep purple-violet.

186. **S. iodantha.** Stem 0.9 to 1.5 m. high, puberulent, much branched above: leaves short-acuminate, serrate, the larger ones 7 cm. long, 4.75 cm. broad, sparingly pubescent above, canescent beneath, slender-petioled: racemes long, rather loosely flowered, subsecund, 1 to 2 dm. long; verticels 6–10-flowered, all remote, the lowest 3 to 4 cm. apart: pedicels slender, about equalling the calyx: calyx in anthesis 5 mm. long, slightly hispid on the nerves and glandular-dotted; lobes very short, broad-ovate, mucronate-acuminate: corolla villous, 2 cm.

long; the galea exceeding the drooping lip: stamens and style exserted, glabrous. — MORELOS, mountain side above Cuernavaca, alt. 707 m., Feb. 5, 1899 (*C. G. Pringle*, no. 8039).

++ Leaves ovate-lanceolate; corolla flesh-colored.

187. **S. michoacana.** Shrub 1.5 to 3 m. high, the branches puberulent: leaves 0.3 to 1.2 dm. long, 1 to 6 cm. broad, long-acuminate, minutely pilose or glabrate above, canescent or glabrate beneath, slender-petioled: racemes dense, 1.5 dm. or less long; the lower verticels often in the axils of the upper leaves: calyx in anthesis 4 mm. long, otherwise as in the last: corolla villous, slender, 2 to 2.5 cm. long; the galea exceeding the lip: stamens and style exserted, glabrous. — MICHOACAN, dry wooded hills near Patzcuaro, Nov. 12, 1890, and Nov. 24, 1891 (*C. G. Pringle*, nos. 3600, 3946): JALISCO, between San Sebastian and the summit of Mt. Bufa de Mascota, alt. 1,380 to 2,150 m., March 20, 1897 (*E. W. Nelson*, nos. 4102, 4104).

○ ○ Leaves velutinous or lanate beneath.

+ Leaves serrate: calyx setulose-hispid or glabrate, with short broad mucronate lobes.

188. S. NERVATA, Mart. & Gal. l. c. 77; Benth. l. c. 339; Hemsl. l. c. 561; Briq. l. c. *S. monochila*, Donnell Smith, Bot. Gaz. xxiii. 13. — Southern Mexico and adjacent Central America. GUATEMALA, Tondos Santos, Dept. Huehuetenango, alt. 3,080 m., Dec. 26, 1895 (*E. W. Nelson*, no. 3635). Originally from OAXACA. Capt. Smith distinguishes his *S. monochila* from *S. nervata* by its pubescent calyx and scarlet corolla. In the specimen of Nelson's no. 3635 at hand, however, the corolla is distinctly purple, not scarlet, and there seems little else to keep the two apart.

++ Leaves crenate: calyx glandular-villous; the lobes long-acuminate.

189. S. KARWINSKII, Benth. Lab. 725, & in DC. l. c. 345; Hemsl. l. c. 558; Briq. l. c. — Described from "Mexico." Not seen.

○ ○ ○ Of close affinity to the preceding but not identified is

190. S. EXCELSA, Benth. Bot. Reg. xxvii. Misc. 90, & in DC. l. c. 342, described from GUATEMALA and said to be near *S. tubifera* but with the 2–4-flowered verticels in an elongated loose raceme.

2. Pubescence stellate.

191. **S. Rosei.** Shrub with dark gray bark; branches canescent with minute stellate pubescence: leaves ovate, appressed-serrate, blunt or

acute, 3.5 to 6 cm. long, dull and sparingly puberulent above, closely canescent-puberulent beneath; petioles canescent, 2 cm. or less long: racemes simple, 1dm. or less in length; verticels 2–6-flowered: pedicels slender, 2 to 4 mm. long: calyx canescent, in anthesis 1.2 to 1.3 cm. long, the tube becoming corrugated at base, broadened above, twice exceeding the ovate-lanceolate acuminate subequal lobes: corolla 2.5 to 3 cm. long, purple-violet, villous, the tube twice exceeding the calyx; the lip one half as long as the galea: style long-exserted, villous. — JALISCO, between Colotlan and Bolaños, Sept. 8, 1897 (*J. N. Rose*, no. 2844).

= = Corolla scarlet or vermilion, without purple tinge.

a. Upper lip of calyx prolonged into a subulate awn, nearly or quite equalling the calyx-tube; lower lip with 2 short subulate teeth.

192. S. CINNABARINA, Mart. & Gal. l. c. 63; Benth. l. c.; Hemsl. l. c. 554; Briq. l. c., & Ann. Conserv. Jard. Bot. Genève, ii. 169 (including varieties). — Southern Mexico and Central America. OAXACA, near Oaxaca, alt. 2,310 to 2,920 m., Sept., 1894 (*E. W. Nelson*, no. 1345) Sierra de San Felipe, alt. 460 m., Oct. 5, 1894 (*C. G. Pringle*, no. 4947); San Juan del Estado, alt. 2,300 m., Nov. 4, 1894 (*L. C. Smith*, no. 273): CHIAPAS (*Ghiesbreght*, nos. 72, 757): GUATEMALA, San Miguel Uspantan, Dept. Quiché, alt. 1,850 m., Apr., 1892, and Buena Vista, Dept. Santa Rosa, alt. 1,700 m., Dec., 1892 (*Heyde & Lux* in exsicc. J. D. Smith, nos. 3118, 4381).

b. Calyx-lips subequal.

1. Calyx-lobes subulate tipped.

193. S. ELEGANS, Vahl. Leaves mostly broad-ovate, subtruncate or rounded at base, rarely exceeding 7 cm. in length: rhachis and calyces sordid glandular-villous. — Enum. i. 238, 362; DC. l. c. 342; Hemsl. l. c. 555; Briq. in Engl. & Prantl, l. c. *S. incarnata*, Cav. Ann. Cienc. Nat. ii. 112; HBK. l.c. 293, t. 144; not Etling. *S. microculis*, Poir. Dict. vi. 614. *S. punicea*, Mart. & Gal. l. c. 65. *S. microcalyx*, Scheele, Linnaea, xxii. 589. *S. longiflora*, Sessé & Moc. l. c. 8. — Central and southern Mexico. Without locality (*Coulter*, no. 1097): GUANAJUATO, without locality, Dec., 1827 (*Berlandier*, no. 1319); oak woods (*Hartweg*, no. 162): QUERETARO, Nov. 13, 1827 (*Berlandier*, no. 1245): MEXICO, Santa Fé, July 24, 1865 (*Bourgeau*, no. 489); woods of Maromenas, Oct. 11, 1865 (*Bourgeau*, no. 1111); Valley of Mexico (*Schaffner*, no. 395); woods of Eslava, alt. 2,400 m., Jan. 31, 1899 (*C. G. Pringle*, no. 7711): MICHOACAN, Tlalpajahua

(*Graham*); rich cañons, hills near Patzcuaro, Dec. 22, 1891 (*C. G. Pringle*, no. 3981): VERA CRUZ, Mt. Orizaba (*Botteri*, no. 578), alt. 3,080 m., Aug. 5, 1891 (*Seaton*, no. 514); Cruz Verde, near Jalapa, alt. 2,130 m., 1894 (*C. L. Smith*, no. 1480): GUERRERO, near Chilpancingo, alt. 2,770 to 3,140 m., Dec. 24, 1894 (*E. W. Nelson*, no. 2245): OAXACA, Sierra de San Felipe, alt. 3,080 m., Aug. 8, 1894 (*C. G. Pringle*, no. 5779).

Var. **sonorensis.** Leaves long-acuminate, mostly cuneate at base, about 1 dm. long: rhachis and calyces pilose, only slightly glandular. — SONORA, Alamos, 1890 (*Edw. Palmer*, no. 292); Huehuerachi, alt. 1,230 m., Dec. 6, 1890 (*C. V. Hartman*, no. 312): damp cañon, Rincanardo Mts., Dec. 27, 1890 (*F. E. Lloyd*, no. 449): CHIHUAHUA, Hacienda San Miguel, 1885 (*Edw. Palmer*, no. 270); near Batopilas, alt. 1,690 to 2,000 m., Oct. 4, 5, 1898 (*E. A. Goldman*, no. 206).

2. Calyx-lobes not subulate-tipped.

○ Bracts 2 to 3 cm. long, persistent.

194. S. MOLLISSIMA, Mart. & Gal. l. c. 71; Benth. l. c. 342; Hemsl. l. c. 561. — Described from OAXACA. Not seen.

○ ○ Bracts smaller, deciduous.

195. S. COCCINEA, Juss. Stems canescent-puberulent. — Juss. ex. Murr. Comm. Gott. i. (1778) 86, t. i.; Benth. l. c.; Regel, Gartenfl. vii. t. 232; Morren, Belg. Hort. ix. t. 5; Gray, Syn. Fl. l. c. 368; Hemsl. l. c. 555; Briq. l. c. *S. rosea*, Vahl, l. c. 244. *S. glaucescens*, Pohl, Fl. Bras. Ic. ii. 136, t. 192. — Of broad range in the Southern United States, the West Indies, South America, and India, rare in Mexico. Reported by Benth. l. c. from Matamoros, TAMAULIPAS.

Var. PSEUDO-COCCINEA, Gray. Stems conspicuously hirsute. — Syn. Fl. l. c. *S. pseudo-coccinea*, Jacq. Coll. ii. 302, & Ic. Rar. ii. 2. t. 209; Hook. Bot. Mag. t. 2864; Benth. l. c.; Paxton, Fl. Gard. ii. t. 40; Briq. l. c. *S. ciliata*, Benth. Lab. 286. *S. Galeottii*, Mart., in Mart. & Gal. l. c. 75. — Central and southern Mexico and Central America. NUEVO LEON, Papagallas, Dec., 1852 (*Geo. Thurber*, no. 872); Guajuco, March, 1880 (*Edw. Palmer*, no. 1074): SAN LUIS POTOSI, near Tancanhuitz, alt. 370 m., May 1, 1898 (*E. W. Nelson*, no. 4376); OAXACA, Chiquihuitlan, alt. 1,230 m., Aug. 16, 1895 (*L. C. Smith*, no. 619): CHIAPAS (*Ghiesbreght*, no. 752); valley of Jiquipilas, alt. 675 to 820 m., Aug., 1895 (*E. W. Nelson*, no. 2942): YUCATAN, Chichen Itza, Jan. 18, 1895 (*C. F. Millspaugh*, no. 116); Izamal, 1895 (*G. F. Gaumer*, no. 453).

Var. **minima.** Low, subsimple, resembling the last, but the leaves very small, rarely exceeding 2 cm. in length, densely long-setulose above. — CHIAPAS, table-land about Ocuilapa, alt. 1,040 to 1,170 m., Aug. 21, 1895 (*E. W. Nelson*, no. 3062).

+ + Leaves cordate. (*S. coccinea* may be looked for here.)

++ Corolla purple or flesh-colored: calyx in anthesis 2 to 2.5 cm. long, with elongate setiform tips to the lobes.

196. S. ARISTULATA, Mart. & Gal. l. c. 67; Benth. l. c. 340; Hemsl. l. c. 553, Briq. l. c. *S. longistyla*, Benth. l. c. 344; Hemsl. l. c. 560; Briq. l. c. — Southern Mexico. JALISCO, mountains near Lake Chapala, Dec. 16, 1889 (*C. G. Pringle*, no. 2421): OAXACA, Valley of Oaxaca, alt. 1,570 m., Nov. 14, 1894 (*L. C. Smith*, no. 306); near Tlapancingo, alt. 1,850 to 2,460 m., Dec. 7, 1894 (*E. W. Nelson*, no. 2085).

++ ++ Related to the above but of doubtful affinity is

197. S. OTTONIS, Lehm. in E. Otto, Hamb. Gartenz. vi. 350; Regel, Gartenfl. vii. 129, & Bot. Zeit. xi. 335.

++ ++ ++ Corolla scarlet or vermilion.

= Calyx in anthesis 1.75 to 2 cm. long.

a. Leaves white-tomentose beneath.

198. S. INCANA, Mart. & Gal. l. c. 68; Benth. l. c. 344; Hemsl. l. c. 558. — Described from PUEBLA. Not seen.

b. Leaves slightly pilose on the nerves beneath.

199. S. TUBIFORMIS, Link, Kl. & Otto, Ic. Rar. 70, t. 28; Benth. l. c. 334, under *S. rectiflora*. *S. rectiflora*, Hemsl. l. c. 564, in part, not Vis. — Described and figured from garden specimens. Perhaps native of Mexico.

= = Calyx in anthesis 1 cm. long.

200. **S. cyclophylla.** Shrub with dark brown bark; branches glandular-hispid: leaves from suborbicular to broad-ovate, rounded or bluntish at tip, crenate, 6 to 7 cm. across, minutely pilose above, more densely so beneath, all but the uppermost on slender petioles 3 to 4 cm. long: raceme 5 to 6 cm. long, the 4–8-flowered verticels 1.5 to 2 cm. apart: pedicels 3 mm. long, hirsute: calyx glandular-hirsute on the veins; the tube twice exceeding the lobes; upper lip suborbicular, blunt or mucronate, lower with ovate mucronate-acuminate lobes: corolla pilose, 2.5 to 2.75 cm. long; the tube once and a half longer than the calyx;

the short blunt galea equalling the lip: style barely exserted, bearded. — Between Tlapancingo, OAXACA and Tlalixtaquilla, GUERRERO, alt. 1,240 to 1,600 m., Dec. 9, 1894 (*E. W. Nelson*, no. 2093, in part.)

++ ++ ++ ++ Related to the above is

201. S. GLUMACEA, HBK. l.c. 298, a very doubtful species probably of this group, the corolla, however, being unknown. Described from "New Spain."

F. Hastatae, Benth. Perennial herbs: leaves mostly or entirely basal, hastate or angulate-cordate: racemes simple or commonly branching, glutinous-villous: corolla blue; the tube ventricose, ampliate above.

* Calyx in anthesis 1.3 to 1.8 cm. long: corolla 4.5 to 6 cm. long: leaves from broad-hastate to rounded at base, pubescent on both faces.

202. S. PATENS, Cav. Ic. v. 33, t. 454; Lindl. Bot. Reg. xxv. t. 23; Hook. Bot. Mag. t. 3808; Paxton, Mag. vi. 1; Benth. l. c. 348; Planch. Fl. des Serres, v. t. 503; Hemsl. l. c. 562; Briq. l. c. 284. *S. grandiflora*, Née ex Cav. l. c. *S. spectabilis*, HBK. l. c. 304. *S. macrantha*, Schl. Ind. Sem. Hort. Hal. 1841. *S. decipiens*, Mart. & Gal. l. c. 64. *S. staminea*, Mart. & Gal. l. c. 65. *S. glutinosa*, Sessé & Moc. l. c. 7, not L. — Central Mexico. Without locality (*Coulter*, no. 1102): SAN LUIS POTOSI, mountains of San Miguelito, 1876 (*Schaffner*, no. 676); without locality, alt. 1,850 to 2,460 m., 1876 (*Parry & Palmer*, no. 759): GUANAJUATO, rocky hillsides, Guanajuato, Aug., 1894 (*A. Dugès*, no. 228).

* * Calyx in anthesis 5 to 8 mm. long.

+ Leaves villous beneath; the margins crenate.

++ Calyx-lobes elongated, subulate-aristate: leaves angulate-lobed.

203. S. VITIFOLIA, Benth. Lab. 724, & in DC. l. c.; Hemsl. l. c. 566; Briq. l. c. — Southern Mexico. VERA CRUZ, Maltrata, alt. 1,700 m., Aug. 16, 1891 (*Seaton*, no. 376): OAXACA, Sierra de San Felipe, alt. 2,310 m., May 26, 1894 (*C. G. Pringle*, no. 4659), Sept. 1, 1894 (*E. W. Nelson*, no. 1169); San Juan del Estado, alt. 2,160 m., June 4, 1894 (*L. C. Smith*, no. 169); Cañada de San Gabriel, Etla, alt. 600 m., June 13, 1897 (*C. Conzatti*, no. 328).

++ ++ Calyx-lobes short-aristate: leaves generally slightly or not at all angulate-lobed.

204. S. CACALIAEFOLIA, Benth. l. c.; Hemsl. l. c. 554; Briq. l. c. — CHIAPAS, in pine forests (*Ghiesbreght*, no. 754); near San Cristobal, alt. 2,160 to 2,700 m., Sept. 18, 1895 (*E. W. Nelson*, nos. 3290, 3236 *g*).

← ← Leaves short-pilose beneath; margins subentire.

205. **S. atriplicifolia.** Tall, 1 m. high: stem glandular-pilose, especially above, leafy nearly to the inflorescence: leaves broadly angulate-deltoid, acuminate, glabrate above, pale beneath, mostly 1 dm. long and broad, on pilose petioles 5 cm. or less in length: inflorescence paniculate, 2.5 to 3 dm. long; the verticels mostly 2-flowered, a little remote: bracts linear, glandular-hispid, 2 mm. long: pedicels 5 mm. long: calyx glandular-puberulent, with ciliate margins, in anthesis 5 mm. long, the ovate-lanceolate lobes with short-subulate tips; upper lip 2–3-dentate: corolla pilose, dark blue, 3 cm. long: style glabrous. — CHIAPAS, among the mountains, flowering in October (*Ghiesbreght*, no. 759).

Section IX. PYCNOSPHACE, Benth. Bracts imbricated. Calyx ovate; the upper lip tridentate, the lower bifid, all the teeth spinescent. Corolla-tube pilose-annulate within; the galea erect, emarginate-bifid; the lip with small lateral lobes, the larger middle one lacerate-fimbriate or dentate. Herbs with flowers in dense glomerules or verticels.

* Leaves deeply pinnatifid: verticels 1 or 2.

206. S. COLUMBARIAE, Benth. Lab. 302, & in DC. l. c. 349; Gray, Syn. Fl. l. c. 367; Briq. l. c. — Southwestern United States and adjacent Mexico. LOWER CALIFORNIA, San Quentin, 1889 (*Edw. Palmer*, no. 620).

* * Leaves crenate.

207. S. LEONIA, Benth. Lab. 303, & in DC. l. c.; Hemsl. l. c. 559; Briq. l. c. *Leonia salvifolia*, Llav. & Lex. Nov. Veg. Descr. fasc. 2, 6. — Described from "Santa Rosa."

Section X. HETEROSPHACE, Benth. Calyx tubulose, the upper lip truncate, tridentate. Corolla-tube pilose-annulate within or rarely subnaked; the galea short, erect, the lower lip with small somewhat spreading lateral lobes. Herbs with loose racemes of few-flowered verticels.

* Corolla scarlet: stems hirsute: leaves petioled, reniform-cordate, repand-toothed or pinnatifid.

208. S. ROEMERIANA, Scheele, Linnaea, xxii. 586; Torr. Bot. Mex. Bound. 132; Gray, Syn. Fl. l. c. 367; Hemsl. l. c. 564; Briq. l. c. 285. *S. porphyrantha*, Decne. Rev. Hort. ser. 4, iii. 301, t. 16; Planch. Fl. des Serres, xi. t. 1080. *S. porphyrata*, Hook. Bot. Mag. t. 4939. — Texas and adjacent Mexico. CHIHUAHUA, Sta. Eulalia Mts., March 27, 1885 (*C. G. Pringle*): COAHUILA, mountains near Saltillo, July, 1880

(*Edw. Palmer*, no. 1073): NUEVO LEON, limestone hills, near Monterey, July 16, 1889 (*C. G. Pringle*, no. 2869).

** Corolla blue: stems lanate: leaves sessile, coarsely and pungently dentate.

209. S. CALIFORNICA, Brandegee, Proc. Cal. Acad., ser. 2, ii. 197.— LOWER CALIFORNIA, Calmalli, Cardon Grande, Apr. 23, 1889 (*T. S. Brandegee*).

INDEX TO THE NUMBERED SPECIMENS OF SALVIA CITED IN THIS PAPER.

(The first number indicates the specimen; the second, in parentheses, the number of the species in the preceding synopsis.)

Lloyd, 449 (193); 451 (115); 452 (24).
Millspaugh, 18 (8); 90 (3); 116 (195).
Nelson, 6 (150); 132 (67); 177 (67); 189 (184); 701 (43); 958 (18); 1100 (162); 1103 (118); 1169 (208); 1175 (63); 1183 (158); 1244 (130); 1289 (118); 1342 (185); 1345 (192); 1387 (50); 1448 (110); 1501 (184); 1511 (105); 1521 (135); 1587 (129); 1595 (104); 1782 (53); 1783 (110); 1794 (86); 1898 (103); 1915 (93); 1917 (136); 1972 (135); 2005 (116); 2049 (130); 2064 (55); 2068 (167); 2085 (196); 2086 (27); 2087 (184); 2091 (135); 2093 (152, 200); 2146 (55); 2186 (182); 2220 (55); 2235 (110); 2245 (193); 2300 (68); 2508 (148); 2668 (76); 2898 (128); 2922 (29); 2942 (195); 3062 (195); 3138 (176); 3142 (43); 3166 (137); 3171 (156); 3191 (41); 3201 (175); 3230 (204); 3236 g (204); 3374 (54); 3401 (184); 3427 (156); 3429 (130); 3478 (184); 3484 (184); 3507 (130); 3635 (188); 3786 (165); 4057 (107); 4072 (7); 4081 (107); 4093 (150); 4012 (187); 4103 (21); 4104 (187); 4171 (20); 4247 (66); 4376 (195); 4527 (100); 4557 (138); 4566 (52); 4651 (40); 4663 (136); 4679 (104); 4755 (138); 4807 (127); 4812 a (138); 4850 (46); 4969 (36); 6315 (141).
Palmer [1870], 7 (101).
Palmer [1880], 1062 (11); 1064 (94); 1067 (100); 1068 (100); 1069 (100); 1072 (94); 1073 (208); 1074 (195); 1079 (136); 1096 (70); 1097 (40); 1098 (40).
Palmer [1885], 64 (9); 96 (75) 154 (75); 157 (75); 205 (24); 259 (61); 270 (193); 290 (166); 379 (139).
Palmer [1886], 28 (83); 53 (30); 61 (33); 183 (121); 184 (120); 226 (29); 488 (75); 498 (7); 556 (44); 598 (59); 659 (53); 662 (184).
Palmer [1887], 320 (10).
Palmer [1889], 620 (206); 684 (97).
Palmer [1890], 10 (3); 292 (193); 345 (108); 680 (9); 681 (9); 682 (24); 878 (101).
Palmer [1892], 1964 (72).
Palmer [1895], 244 (3).
Palmer [1896], 305 (37); 327 (36); 404 (136); 417 (147); 446 (86); 451 (28); 572 (11); 757 (53); 844 (138); 967 (53).
Palmer [1898], 107 (100); 153 (147); 161 (138); 194 (94); 334 (38); 335 (11); 336 (36); 640 (142); 640½ (139); 726 (136); 1071 (147).
Parry, 26 (147); 29 (94).
Parry & Palmer, 698 (89); 729 (47); 730 (103); 731 (104); 736 (28); 740 (145); 741 (136); 743 (11); 744 (36); 745 (52); 746 (52); 746½ (11); 747 (138); 748 (138); 750 (98); 751 (96); 751½ (98); 752 (118); 753 (98); 754 (142); 755 (157); 756 (86); 757 (166); 758 (166); 759 (202); 760 (32); 761 (31).
Pringle, 52 (95); 239 (139); 556 (11); 637 (139); 654 (36); 659 (100); 1727 (7); 1764 (138); 1798 (75); 2297 (26); 2384 (136); 2421 (196); 2458 (184); 2463 (59); 2555 (83); 2560 (121); 2817 (118); 2818 (63); 2824 (166); 2869 (208); 2913 (30); 3058 (120); 3153 (118); 3157 (166); 3170 (98); 3206 (104); 3224 (63); 3273 (104); 3593 (107); 3600 (187); 3681 (40); 3683 (53); 3946 (187); 3954 (43); 3981 (193); 4097 (107); 4150 (39); 4155 (81); 4163 (29); 4200 (40); 4227 (150); 4258 (127); 4278 (51); 4298 (138); 4351 (109); 4564 (154); 4624 (44); 4659 (208); 4705 (158); 4763 (105); 4772 (162); 4845 (65); 4862 (130); 4947 (192); 4953 (63); 4960 (135); 4991 (185); 5176 (11); 5624 (26); 5643 (119); 5654 (146); 5779 (193); 6013 (110); 6240 (129); 6245 (92); 6251 (93);

II. — A REVISION OF THE MEXICAN AND CENTRAL AMERICAN SOLANUMS OF THE SUBSECTION TORVARIA.

Dunal's subsection *Torvaria* of the genus *Solanum* has never been understood in America. Almost without exception the many diverse forms from equally diverse regions have been in American herbaria placed under the type species *Solanum torvum*, Swartz. This treatment as a single polymorphous species of all the plants of similar subgeneric character, — a course by no means without precedent in other sections of *Solanum* and scores of other tropical American genera, — has been due to a lack of authentic material and of any more concise statement of the specific characters than can be found in the rather ponderous monograph of Dunal. An accumulation of specimens from many sources has made it possible to divide the Mexican material passing in the Gray Herbarium as *Solanum torvum* into species of marked morphological characters and restricted geographical ranges. Most of these plants thus separated are found to agree very well with the descriptions of different species recognized from Mexico by Dunal in his monograph, though three species there characterized have not yet been identified with modern herbarium material. Doubtless these identifications of modern Mexican specimens with the old descriptions cannot all be taken as final, and a study of the type specimens, when it is possible to examine them, may prove the present conclusions to be in some cases inaccurate. Yet confidence is felt that the present understanding of the group is much clearer than that which has prevailed among recent students of Mexican botany. With the hope of simplifying the future study of the group the following synopsis is presented of the Mexican species of the section as now interpreted.

* Pubescence of flowering branches densely stellate-tomentose, hairs short and fine.

+ Pedicels bearing simple gland-tipped hairs among the stellate ones. (See also *S. ochraceo-ferrugineum*.)

S. TORVUM, Swartz. Branches slightly armed, canescent-ochraceous, the young parts, especially, ochraceous: leaves subcordate-ovate, shallowly sinuate-lobed, olive-green and stellate-scabrous above, canescent and stellate-tomentose beneath, 1 to 1.5 dm. long, 6 to 12 cm. broad, often sparingly armed on the midrib beneath, more rarely so above:

corymb generally bifid or trifid, many-flowered, cymose, the fruiting pedicels mostly ascending. — Prodr. 47; Dunal, Sol. 203, t. 23, & in DC. Prodr. xiii. 260. — Originally described from the West Indies, where it is common. In Mexico known only from the South. CHIAPAS, near Huehuetan, alt. 150 to 615 m., Feb. 22, 1896 (*E. W. Nelson*, no. 3830).

Var. RUBIGINOSUM, Dunal, l.c. 261, described from Guatemala, apparently differs from the species only in its more ferrugineous pubescence. — GUATEMALA, Rio Dulce, Depart. Livingston, March, 1889 (*J. Donnell Smith*, no. 1840): NICARAGUA (*C. Wright*).

S. HERNANDESII, Moc. & Sessé. More spiny throughout, the branches more loosely sordid-tomentose: leaves deeply and sinuately 5–7-lobed, the lobes sometimes pinnatifid: inflorescence at first subcorymbose, simple or bifid, becoming distinctly racemose: fruiting pedicels spreading. — Moc. & Sessé in Dunal, l. c. 266. — CHIAPAS, mountains near Tonala, alt. 600 to 1,050 m., Aug. 14, 1895, table land about Ocuilapa, alt. 1,050 to 1,170 m., Aug. 21, 1895 (*E. W. Nelson*, nos. 2904, 3029): GUATEMALA, San Miguel Uspantán, Depart. Quiché, alt. 1,850 m., April, 1892 (*Heyde & Lux* in exsicc. J. D. Smith, no. 3446): NICARAGUA (*C. Wright*).

S. madrense. Shrubby, the young branches loosely stellate-tomentose with canescent or ochraceous hairs, and armed with straight or slightly curved prickles: leaves thick, ovate to ovate-lanceolate, acuminate, unequally subcordate at base, subentire or bluntly and shallowly sinuate-angulate, without the petiole (1 to 3 cm.) 5 to 15 cm. long, 4 to 13 cm. wide, above olive-green, stellate-scabrous, beneath a little paler and tomentulose, sometimes slightly armed; young leaves often aureate-tinged, and velutinous: inflorescences extra-axillary, in maturity 4 to 9 cm. long, simple or bifid, scorpoid-racemose; the pedicels glandular hairy, spreading and reflexed in fruit: calyx-lobes lanceolate, long-acuminate: corolla 2 cm. long, 3 cm. broad, whitish, deeply lobed, the lobes lanceolate or lance-ovate, acutish: filaments very short; anthers subequal, slender, 8 or 10 mm. long: the style somewhat longer: berry apparently black, glabrous, 1 to 1.5 cm. in diameter. — *S. diversifolium*, Wats. Proc. Am. Acad. xxi. 434, not Schl. *S. torvum*, Wats. l. c. xxii. 441, not Swartz. — The common representative of the group in the Sierra Madre and westward to the Pacific. SONORA, Sierra de los Alamos, March 25 to Apr. 8, 1890 (*Edw. Palmer*, nos. 363, 364): CHIHUAHUA, Hacienda San Miguel, 1885 (*Edw. Palmer*, no. 22): TEPIC, San Blas, June 6, 1897 (*E. W. Nelson*, no. 4335): SINALOA, Mazatlan,

Dec. 1894, and Isla Piedra, near Mazatlan, Dec. 31, 1894 (*Frank H. Lamb*, nos. 336, 336[a]); Rosario, June 20, 1897, and foothills of the Sierra Madre, near Colomas, July 20, 1897 (*J. N. Rose*, nos. 1402, 1777): JALISCO, barranca near Guadalajara, June, 1886 (*Edw. Palmer*, no. 106); near Guadalajara, Nov. 14, 1888, May 27, 1891 (*C. G. Pringle*, nos. 2193, 5140 [type]); mountains near Talpa, alt. 1,200 to 1,540 m., March 7, 1897, Maria Madre Isl., May 3–25, 1897 (*E. W. Nelson*, nos. 4040, 4185): COLIMA, Colima, Jan. 9–Feb. 6, 1891 (*Edw. Palmer*, no. 1179): GUERRERO, Acapulco, Nov. 1894 (*Edw. Palmer*, no. 148).

+ + Pedicels not glandular.

++ Pubescence of branches and lower face of leaves whitish-lanate.

S. HARTWEGI, Benth. Essentially unarmed, branches rarely with a few spines: leaves from oblong-lanceolate to ovate, entire or sinuate-repand, acuminate, pale green above, the younger stellate-velutinous, the older scabrous: cymes many-flowered, the branches scorpoid; peduncles pedicels and calyx white-lanate; fruiting pedicels mostly erect: ripe fruit red, glabrous, 1 cm. or more in diameter. — Pl. Hartw. 68; Dunal, l. c. 262. *S. torvum*, var. *lanatum*, Dunal, l. c. 261. — Hartweg's original specimen was from Hacienda del Carmen. Dunal's variety was based upon a Guatemala specimen. The following are referred here: MEXICO, Valley of Mexico, Nov. 27, 1865 or 1866 (*Bourgeau*, no. 725): VERA CRUZ, Valley of Cordova, Jan. 16, 1865 or 1866 (*Bourgeau* no. 1671) ; region of Orizaba, May to July (*Bourgeau*, nos. 2408, 2556, *Botteri*, nos. 82, 1083, *Seaton*, no. 142); Santa Lucretia, Isthmus of Tehuantepec, Feb., 1895 (*C. L. Smith*, no. 1071): OAXACA, hills near Oaxaca, alt. 1,850 m., Sept. 8, 1894 (*C. G. Pringle*, no. 4891); Monte Alban, alt. 1,690 m., Nov. 24, 1894 (*L. C. Smith*, no. 341); near Totontepec, alt. 1,690 m., vicinity of Choapam, alt. 1,170 to 1,385 m., vicinity of Yalalag, alt. 1,230 to 2,400 m., July, 1894 (*E. W. Nelson*, nos. 788, 835, 952); Tillantongo, Dec. 12, 1895 (*Ed. Seler*, no. 1591): GUATEMALA, San Siguán, Depart. Quiché, alt. 1,785 m., May, 1892 (*Heyde & Lux* in exsicc. J. D. Smith, no. 3446): COSTA RICA, Cartago, Prov. Cartago, alt. 1,300 m., Nov., 1887 (*Juan J. Cooper* in exsicc. J. D. Smith, no. 5872). Palmer's no. 637 from San Luis Potosi, 1878, may be an attenuated form of this.

++ ++ Pubescence ochraceous or fuscous.

= Branches more or less armed.

S. FENDLERI, Van Heurck & Müll. Arg. Sparingly armed: pubes-

cence of young branches leaves and calyx ochraceo-ferrugineous, pulverulent: leaves rhombic-ovate, shallowly sinuate-angled, 6 to 8 cm. long, 4 to 5.5 cm. broad: inflorescence closely flowered. — Van Heurck & Müll. Arg. in Van Heurck, Obs. 130. — PANAMA, Chagres, Feb., March, 1850 (*A. Fendler*, no. 254).

S. ochraceo-ferrugineum. Stems 1.5 to 3 m. high, armed with stout broad-based deltoid prickles: young branches leaves and calyces ochraceo-ferrugineous, densely velutinous-tomentose rarely a little glandular: leaves oblong-ovate, shallowly sinuate-angled or lobed, 7 to 16 cm. long, 4.5 to 12 cm. broad, paler and more tomentose beneath than above: inflorescence loosely many-flowered: calyx in anthesis 8 or 10 mm. long, deeply 5-parted into deltoid-lanceolate acuminate lobes: corolla 3 cm. broad: anthers slender, subequal, 6 or 7 mm. long: berries glabrous, 1 cm. or more in diameter. — *S. obtusifolium*, Benth. Pl. Hartw. 23, not HBK. *S. torvum*, var. *ochraceo-ferrugineum*, Dunal, l. c. 260. — GUANAJUATO, Guanajuato, 1837 (*Hartweg*, no. 204), 1880, 1883 (*A. Dugès*): TAMAULIPAS, San Luis Potosi to Tampico, Dec., 1878 to Feb., 1879 (*Edw. Palmer*, no. 639½); VERA CRUZ, old fields and recently cleared grounds, Wartenburg, near Tantoyuca, 1858 (*Ervendberg*, nos. 285, 485).

S. DIVERSIFOLIUM, Schlecht. Sparingly armed: branches petioles and inflorescences cinereous stellate-tomentulose: leaves oblong-ovate, bluntly acuminate, with rounded bases, olive-green and stellate-scabrous above, cinereous-tomentulose or pulverulent beneath, 7 to 20 cm. long, 4 to 12 cm. broad, subentire or slightly undulate, rarely shallowly sinuate: inflorescence subaxillary, simple or branched, becoming 6 to 9 cm. long, extremely floriferous, the pedicels after anthesis mostly strongly reflexed or drooping. — Linnaea, xix. 297; Dunal, l. c. 262. — Originally described from Papantla, VERA CRUZ. The following are referred here; Mexico, without locality (*Coulter*, no. 1245): SAN LUIS POTOSI, hills, Las Canoas, Aug. 21, 1891 (*C. G. Pringle*, no. 3901, doubtfully referred here): VERA CRUZ, Valley of Cordova, Dec. 26, 1865 or 1866 (*Bourgeau*, no. 1608); Orizaba (*Botteri*); near Motzorongo, Feb. 22, 1894 (*E. W. Nelson*, no. 149): OAXACA, Paso de Canoa, Tuxtepec, alt. 150 m., Aug. 28, 1895 (*Conzatti*, no. 133, *L. C. Smith* no. 669).

= = Branches unarmed.

S. Hayesii. A small tree: the young branches finely but densely invested with short ochraceo-cinereous stellate hairs: upper leaves geminate and unequal, ovate to ovate-oblong, acuminate, unequal and sub-

cordate or rounded at base, entire or slightly undulate, the larger 1.7 to 2.4 dm. long, 1.1 to 1.4 dm. wide, at first stellate-pubescent above, soon quite glabrous and lucid, cinereous-tomentose beneath; primary nerves 5 to 7 pairs; petioles thick, 2 to 4 cm. long: inflorescence extra-axillary, bifid or trifid, becoming 6 or 8 cm. long, the branches scorpoid-racemose, densely flowered, ochraceo-cinereous; pedicels in fruit becoming strongly deflexed: calyx in anthesis 2 mm. long, with short rounded lobes: corolla densely stellate without, 6 or 7 mm. high, barely 1 cm. broad, with long lanceolate lobes: anthers subequal, lanceolate, truncate, 3 or 4 mm. long: style slightly longer, sparingly stellate-pubescent: berry glabrous or sparingly puberulent, 1 cm. or more in diameter. — PANAMA, Chagres, Jan., 1850 (*A. Fendler*, no. 246); near Gatun, Dec., 1859 (*Sutton Hayes*).

* * Short stellate pubescence of flowering branches mixed with long slender naked hairs.

S. erythrotrichum. Strongly armed with deltoid mostly hooked stout prickles: branches densely reddish-tomentose with appressed stellate hairs and longer naked jointed trichomes: leaves oblong, acuminate, rounded at the base, subentire, 1 to 1.7 dm. long, 3 to 8 cm. wide, ferrugineous-green sparingly stellate and strongly rugose above, tomentulose beneath, at first rufescent, later cinereous, rarely armed on the midrib beneath; primary nerves 5 to 7 pairs; petiole 1.5 to 2.5 cm. long, rufescent: peduncle extra-axillary, 3.5 cm. long, few-flowered, rufescent; pedicels short (7 mm.), thickish: calyx in fruit deeply cut into lanceolate lobes 6 or 7 mm. long: fruit puberulent, becoming glabrate, about 1 cm. in diameter. — GUATEMALA, Coban, Depart. Alta Verapaz, alt. 1,325 m., Feb., 1888 (*H. von Tuerckheim* in exsicc. J. D. Smith no. 1381).

* * * Branches clothed with long stellate-tipped hairs with broad bases.

S. HISPIDUM, Pers. Armed with long stout hooked-prickles, and densely pubescent with ochraceous or fuscous distinct stiff trichomes: leaves ovate, subcordate or attenuate at base, 0.5 to 2 dm. long, subentire or with 5 to 11 sinuate lobes; above ferrugineous with distinct stipitate stellate hairs, or glabrate, and often with long sharp prickles on the nerves; beneath cinereous with similar hairs, the nerves often spiny. — Syn. i. 228; Dunal, l. c. 275. *S. stellatum*, Ruiz & Pav. Fl. Per. ii. 40, t. 176. *S. chrysotrichum*, Schlecht. Linnaea, xix. 304; Dunal, l. c. 276. — From the variable material now at hand it seems impossible to

keep *S. chrysotrichum* separate from Persoon's species. VERA CRUZ, Cordoba, alt. 830 m., Aug. 20, 1891 (*H. E. Seaton*, no. 395); Jico, July 16, 1893 (*E. W. Nelson*, no. 24): Orizaba, Jan. 28, 1894 (*E. W. Nelson*, no. 45): OAXACA, Calderon, alt. 1,850 m., San Juan del Estado, June 18, 1894 (*L. C. Smith*, no. 36); near Reyes, alt. 1,785 to 2,060 m., Oct. 24, 1894 (*E. W. Nelson*, no. 1785): CHIAPAS, near Tumbala, alt. 1,230 to 1,690 m., Oct. 20, 1895 (*E. W. Nelson*, no. 3331): GUATEMALA, Santa Rosa, alt. 925 m., June, 1892, San Miguel Uspantán, alt. 1,850 m., Apr., 1892 (*Heyde & Lux* in exsicc. J. D. Smith, nos. 3441, 3448): COSTA RICA, Cartago, alt. 1,650 m., Dec., 1887 (*Juan J. Cooper*, in exsicc. J. D. Smith, no. 5870).

Three species of the subsection *Torvaria*, described from Mexico, are still obscure and perhaps not recently collected. These are *S. amictum*, Moric. in Dunal l. c. 263; *S. rude-pannum*, Dunal, l. c. 264; *S. Lamberti*, Dunal, l. c. 268.

III. — SOME UNDESCRIBED MEXICAN PHANEROGAMS, CHIEFLY LABIATAE AND SOLANACEAE.

Pelexia Pringlei. Roots clustered, cylindric, whitish, tuberiform, 0.5 to 1 dm. long: leaves 3, at the base of the bracteate scape, long-petioled, with smooth entire oblong to ovate-lanceolate acuminate blades 8 to 12 cm. long, about 4 cm. wide: scape about 3 dm. high, sparingly pubescent above, with about 8 sheathing lanceolate bracts: spike 1 dm. long, rather loosely flowered: bracts lance-acuminate, 3 cm. long, much exceeding the ovary: sepals greenish, lanceolate, acuminate, two of them free and somewhat drooping, 2 cm. long, the others united to form a blunt galea; lip short and rounded, exceeded by the beak of the stigma; spur adnate to the ovary: anther ovate, bluntish, 5 m. long. —VERA CRUZ, wooded hills near Jalapa, alt. 1,230 m., April, 1899 (*C. G. Pringle*, no. 8122). Habitally resembling *P. setacea*, Lindl. (*Neottia calcarata*, Hook. Bot. Mag. t. 3403), but with adnate spur, and shorter blunter sepals galea and lip.

Scutellaria distans. Stems slender, flexuous, 3 to 4 dm. long, somewhat recurved-pilose on the angles; internodes rather long (3 to 5 cm.): leaves firm, sparingly appressed-pubescent or glabrate, fan-shaped, broader than long, upper from deltoid-ovate to rhombic-ovate,

short-acuminate, coarsely crenate above the rounded or truncate base, 2 to 5 cm. long, 2 to 3.5 cm. wide: flowers solitary in the axils, on slightly pilose pedicels 0.5 cm. long: calyx pilose in lines, in anthesis 4 to 5 mm. long: corolla dark blue, arcuate, 2 to 2.5 cm. long, puberulent without; the lower lip slightly longer than the upper, with a white spot in the middle. — JALISCO, in the Sierra Madre, west of Bolaños, Sept. 15–17, 1897 (*J. N. Rose*, no. 2951). Related to the northern *S. galericulata*, L.

S. Rosei. Apparently tall (upper portions of plants at hand 6 to 7 dm. high): stem short cinereous-pubescent: lower leaves suborbicular, rounded at tip, upper ovate, acuminate, coarsely crenate-dentate, rounded or subcordate at base, minutely soft-pubescent on both sides, 4 to 6 cm. long, 3 to 4 cm. wide, on very short pubescent petioles 1 to 3 mm. long: raceme elongated, 2 to 2.5 dm. or more in length: the flowers irregularly scattered, alternate, opposite or fascicled: bracts lanceolate, about equalling the glandular-hirsute pedicels: calyx somewhat glandular-hirsute, in anthesis 3 to 4 mm. long: corolla 2 to 2.5 cm. long, rose-purple above; the pubescent tube pale; the lower lip somewhat exceeding the upper. — SINALOA, foothills of the Sierra Madre, near Colomas, July 20, 1897 (*J. N. Rose*, no. 1784). *Ghiesbreght's* nos. 88 and 803 from CHIAPAS are probably forms of the species, though with smaller corollas.

S. Pedicularis. Stems slender, minutely cinereous-puberulent: leaves oblong or ovate-oblong, coarsely crenate-dentate, short-acuminate and blunt at tip, rounded or subtruncate at base, sparsely pubescent above with short appressed hairs, glabrous beneath, 2 to 3.5 cm. long, 1 to 2 cm. wide, on slender finely-puberulent petioles 1.5 to 2 cm. long: raceme 15–25-flowered, at first dense, resembling *Pedicularis canadensis*: bracts linear or lanceolate, equalling the pedicels (3 to 5 mm. long): calyx puberulous, in anthesis 3 to 3.5 mm. long, in fruit becoming 8 to 9 mm. long: corolla yellowish, 2.5 cm. long, the tube barely 2 mm. in diameter nearly to the slightly broader throat; lower lip a little longer than the upper: seeds roughish, not margined. — CHIAPAS, near Tumbala, alt. 1,230 to 1,700 m., Oct. 20, 1895 (*E. W. Nelson*, no. 3342). The specimens are rather fragmentary, so that the base of the plant cannot now be described. Nearly related to the showy *S. Mociniana*, Benth., which has much longer scarlet corollas.

Stachys (Stachyotypus) flaccida. Ascending or spreading, freely branched, 4 dm. high or more (?): stems minutely pilose or glabrate; internodes 1 dm. long: leaves thin and flaccid, glabrous or minutely appressed-pubescent beneath, the lower on slender petioles, the upper

becoming sessile, deltoid-ovate to oblong, cordate at base, coarsely crenate, 3 to 7 cm. long: verticels 3–6-flowered, remote, only the lower conspicuously leafy-bracteate: pedicels very short: calyx minutely puberulent, in anthesis 6 mm. long, cleft half way to the base into lance-subulate teeth: corolla apparently pale, 1.1 to 1.3 cm. long; the tube once and a half as long as the calyx; the 3-lobed lower lip twice as long as the entire short pubescent galea. — OAXACA, Hacienda de Caciques, District of Cuicatlan, Aug. 4, 1895, alt. 2,150 m. (*L. C. Smith*, no. 612). Apparently related to *S. Drummondii*, Benth.

S. (Calostachys) oaxacana. Stems slender, 2.5 to 6 dm. high, densely retrorse-hispid below, sparingly so or only glandular-puberulent above: leaves deltoid-ovate to deltoid-lanceolate, coarsely crenate, cordate or truncate at base, 1.5 to 3.5 cm. long, above somewhat strigose-pubescent, beneath more or less pubescent, often white with appressed longitudinally spreading stiffish hairs; petioles slender, the lower equalling the blades, the upper shorter: verticels 4–6-flowered, rather remote, only the lowest conspicuously bracteate: pedicels about equalling the calyx: calyx green, glandular-puberulent, in anthesis 5 mm. long, in fruit becoming as broad as long, with 5 deltoid-subulate teeth: corolla scarlet, 2 to 2.5 cm. long, minutely puberulent or glabrate without; the 3-lobed lower lip slightly exceeding the entire or emarginate galea. — OAXACA, near Reyes, alt. 2,060 to 3,080 m., Oct. 20, 1894 (*E. W. Nelson*, no. 1795); Sierra de San Felipe, alt. 2,150 m., Sept. 23, 1895 (*C. Conzatti*, in exsicc. L. C. Smith, no. 709); mountains of San Juan del Estado, alt. 2,300 m., Oct. 21, 1895 (*L. C. Smith*, no. 924); Cuicatlan, alt. 1,675 m., Dec. 9, 1895 (*V. González*, no. 47). Closely related to *S. coccinea*, Jacq., with which it has formerly been confused, but from which it is distinguished by its very slender habit, smaller calyx and different pubescence.

Calamintha oaxacana. Shrub with smooth brown bark, and very slender minutely puberulent or glabrate branchlets: leaves thin, elliptic-ovate, 1 to 1.5 cm. long, finely and sharply serrate, acute at tip, narrowed or rounded at base; petioles filiform, about equalling the leaf-blades: flowers solitary, axillary, on slender 2-bracteate pedicels 5 to 8 mm. long: calyx tubular, 13-costate, in anthesis 6 to 7 mm. long; the tube twice exceeding the lance-subulate lobes; the upper lip with 3 upturned lobes, the two lobes of the lower straighter: corolla red, 3 to 3.25 cm. long, short-pubescent without. — OAXACA, El Parián-Etla, alt. 1,200 m., Nov. 1898 (*V. González* & *C. Conzatti*, no. 901). Nearest related to *C. coccinea* of the southern United States. Habit-

ally somewhat resembling *Gardoquia mexicana*, but with the definitely bilabiate lip of *Calamintha*.

Cunila tomentosa. Stem tall (probably 8 dm. high), sharply quadrangular, freely paniculate-branched, densely tomentose above and on the younger parts: leaves lanceolate to ovate-lanceolate, acuminate, sessile or short-petioled, entire or sparingly appressed-serrate, above puberulent, beneath densely white-tomentose, 2 to 5 cm. long, 1 to 1.5 cm. wide: racemes dense, spiciform, 1 to 4 cm. long, solitary or in 3's, terminating the short branches: pedicels slender, about equalling the calyx: calyx 2 to 3 mm. long; the tube twice or thrice as long as the lance-subulate teeth, densely villous especially within the throat: corolla villous, slightly exceeding the calyx: stamens mostly included. — OAXACA, between Pluma and San Miguel Suchistepec, alt. 1,850 m., March 21, 1895 (*E. W. Nelson*, no. 2495).

Hyptis (Cephalohyptis) madrensis. Stems procumbent, puberulent (densely short-pilose-hirsute on the younger parts), freely branching; internodes 0.5 to 1 dm. long: leaves thickish, oblanceolate to elliptic-obovate, coarsely crenate-dentate above, the subcuneate entire base narrowed gradually to a short petiole, appressed-pilose on both faces, dark green above, pale beneath, 2.5 to 5 cm. long, 1 to 2 cm. broad: peduncles axillary, 3 to 5 cm. long: fruiting head 2 cm. in diameter: bracts foliaceous, lanceolate to oblong, entire or coarsely dentate, 1 cm. or less long: calyx villous, the long subulate teeth setulose. — TEPIC, foothills of the Sierra Madre, near Pedro Paulo, Aug. 3, 1897 (*J. N. Rose*, no. 1958). Resembling, apparently, *H. Parkeri*, Benth., of South America but differing from that in its pubescent leaves and calyx.

H. (Minthidium) Pringlei. Stem 1 m. (?) high, freely branching, more or less pubescent with pilose or somewhat strigose hairs: leaves lanceolate, acute, subsessile or short-petioled, entire, essentially glabrous, 2 cm. or less long: flowers axillary, 2 to 6 in a fascicle: pedicels slender, glabrous, becoming 2 mm. long in fruit: calyx glabrous, campanulate, in anthesis 1.5 mm., in fruit 3 to 4 mm. long, cleft one-third to the base into narrowly deltoid subacuminate lobes: corolla slightly exceeding the calyx. — SAN LUIS POTOSI, Tamasopo Cañon, Aug. 5, 1890 (*C. G. Pringle*, no. 3223). Related to *H. verticillaris*, with which it has been confused, but with axillary flowers.

H. (Minthidium) axillaris. Similar to the preceding: leaves lanceolate or rhombic-lanceolate, 7 cm. or less in length, acuminate, coarsely and irregularly serrate above the middle, entire below and cuneate to petioles 1 cm. or less long, puberulent above, pilose beneath on the

nerves: calyx sparingly pubescent or glabrate, salverform, with shorter broader lobes. — PUEBLA, near Metlaltoyuca, alt. 250 m., Jan. 31, 1898 (*E. A. Goldman*, no. 48).

H. (**Hypenia § Laxiflorae) Nelsonii.** Tall, stem smooth and glossy below, minutely puberulent above: leaves thick, glabrous, rather glaucous, lance-acuminate, slightly auriculate-clasping at base, those of the stem 1.5 to 2 dm. long, with fine short teeth along the margin, the upper much shorter and entire: panicle 4 to 5 dm. long, dichotomous; the lower ascending branches 3 dm. long: bracts ovate-lanceolate, acuminate, puberulent, 1 cm. or less long: ultimate pedicels 0.5 to 1 cm. long: calyx puberulent, campanulate, in anthesis 5 to 6 mm., in fruit 1 cm. long, strongly 13–nerved, slightly bilabiate; the deltoid acuminate lobes one-half as long as the tube: corolla 2 to 2.25 cm. long; the tube constricted below, tubular and slightly enlarged upward; the blunt lobes only 3 or 4 mm. long: styles and anthers exserted, glabrous: nutlets oblong-obovate. — JALISCO, between San Sebastian and the summit of Mt. Bufa de Mascota, alt. 1,850 m., March 20, 1897 (*E. W. Nelson*, no. 4108). A unique plant among the Mexican species, belonging to a section hitherto known only from Brazil and adjacent South America.

Lycium geniculatum. Branches slender, geniculate, covered with pale gray bark; spines slender, on the flowering branches about 8 mm. long, barely 1 cm. apart: leaves very glaucous, glabrous, oblong to obovate, blunt or acute, 2.5 cm. long or less, on slender petioles 1 cm. or less in length: flowers abundant in small cymes, terminating the rather crowded short ultimate branchlets: pedicels 7 to 9 mm. long: calyx glabrous, short campanulate, 2 mm. high, slightly broader, with 5 spreading lance-subulate teeth 1 to 1.5 mm. long: corolla 1.2 cm. long, funnelform, with broad-cordate lobes 4 to 5 mm. long, pubescent within the tube: stamens slightly unequal, a little exserted; filaments pubescent below: fruit 5 to 8 mm. in diameter, red with a bloom. — PUEBLA, near Tehuacan, Nov. 27, 1895 (*C. G. Pringle*, no. 7000). Nearest related, apparently, to *L. cestroides*, Schl., of Brazil.

Margaranthus sulphureus. Annual, glabrous; stem stout and rather fleshy, 4 dm. high, branching above: lower leaves alternate, the upper and those of the branches geminate and unequal, from ovate to broadly rhombic-obovate, subentire or shallowly and bluntly sinuate, the larger 3 to 6 cm. long, 3 or 4 cm. wide, narrowed below to winged petioles varying from 1 to 4 cm. long; upper leaves smaller, sometimes subsessile: flowers generally single from each of the upper axils; pe-

duncle slender, somewhat arcuate, in fruit becoming 0.5 to 1.5 cm. long: calyx in anthesis 3 or 4 mm. long, sparingly pilose, with 5 short deltoid ciliate lobes: corolla campanulate-urceolate, 7 to 10 cm. long, nearly as broad, sulphur-yellow, with purple patches at base: fruiting calyx glabrate, globose, 1 to 1.5 cm. in diameter, the short calyx-tips closely connivent. — MEXICO, borders of ditches, Valley of Mexico, July 10, 1865 or 1866 (*Bourgeau*, no. 111), Valley of Mexico, alt. 2,250 m., Oct. 4, 1899 (*C. G. Pringle*, no. 8215). A much coarser plant than the similar *M. solanaceus*, with larger yellower corolla.

Athenaea Nelsonii. Stems petioles and pedicels glandular-villous, fuscous: leaves solitary or geminate and very unequal, on petioles 8 cm. or less in length, broadly ovate, acuminate, equally or unequally cordate at base, entire, undulate or slightly sinuate-toothed, the larger 2 dm. long, thin, dark green and minutely pubescent above, pale and appressed-pilose beneath, especially on the nerves: flowers in fascicles of 5 to 15: pedicels at first rather short, in fruit becoming 2 to 3 cm. long: calyx thin, glandular-pilose, short-campanulate, in anthesis 5 to 6 mm. high and broad, rounded or subtruncate at base, the tube hardly equalling the 5 deltoid lobes: corolla yellowish, 1.5 to 2 cm. long, deeply cut into oblong ciliate lobes 1 cm. long: filaments broad at base, inserted midway up the throat of the corolla, rather shorter than the oblong anthers (3.5 to 4 mm. long): fruiting calyx becoming 1 cm. in diameter, inclosing the scarlet berry. — CHIAPAS, between Tumbala and El Salto, alt. 460 to 1,385 m., Oct. 29, 1895 (*E. W. Nelson*, no. 3395). A large-leaved species habitally resembling *A. viscosa*, Benth. & Hook. (*Saracha viscosa*, Schrad., Sweet, Brit. Fl. Gard. ser. 2, t. 323), but with smaller more regular calyx, more deeply lobed corolla and much shorter filaments.

Physalis subintegra. Perennial from a very slender root-stock 3 or 4 dm. long, ascending, slightly branching from near the base: stems tough, dark green, sparingly appressed-pubescent with simple hairs or glabrate, about 3 dm. high: leaves from ovate-lanceolate to broadly ovate, 3 to 6 cm. long, 1.5 to 3 cm. broad, entire or slightly repand-dentate, somewhat appressed-pubescent on both surfaces, tapering above to a blunt tip and slightly rounded below to a petiole 0.5 to 2 cm. long: peduncle short, 0.5 to 1 cm. long: calyx in anthesis 7 to 10 mm. long, pubescent, with triangular-lanceolate or ovate acute lobes: corollas pubescent without, the earlier 2.5 cm. broad, the later smaller, sulphur yellow with large dull brown markings at base: one filament slightly exceeding the others, 5 mm. long; anthers oblong, purplish, 2 or 3 mm. long: fruiting calyx globose-ovoid, a little sunken at base, slightly 5-angled, firm and

strongly veiny, 3 to 3.5 cm. long. — MEXICO, Sierra de las Cruces, alt. 3,080 m., Sept. 19, 1899 (*C. G. Pringle*, no. 8225); VERA CRUZ, Orizaba (*Botteri*, no. 207): OAXACA, slopes of Mt. Zempoaltepec, alt. 2,400 to 3,080 m., July 5-10, 1894 (*E. W. Nelson*, nos. 587, 681): JALISCO, between Huejuilla and Monte Escobedo, Aug. 25, 26, 1897 (*J. N. Rose*, nos. 2577, 2606). Nearly related to *P. arenicola*, Kearney, of the southeastern United States.

P. philippensis. Freely branching from a stout woody caudex; the slender branches somewhat ligneous at base, about 2 dm. in length, long-pilose with crisp white jointed hairs: leaves appressed-pubescent above, pilose beneath on the veins and ciliate on the margins, broadly rhombic-obovate, coarsely and bluntly angulate-sinuate, 1 to 3 cm. long, 1 to 2.5 cm. wide, broadly subcuneate below to a broad long-pilose petiole 1 to 1.5 cm. long: peduncles 1 cm. long, pilose: calyx during anthesis about 8 mm. long, white-pilose, cleft into narrowly ovate acutish or blunt lobes: corolla short-campanulate, 1.5 cm. long, 2 to 2.5 cm. broad, whitish or pale yellow, with very broad purplish markings: 2 filaments longer than the others, 7 mm. long; anthers short-oblong, purple and yellow, 3 or 4 mm. long: fruit not seen. — OAXACA, Sierra de San Felipe, alt. 2,617 m., June 1, 1894 (*C. G. Pringle*, no. 5621).

P. sordida. Perennial, densely pubescent all over with short sordid glandular-pilose hairs: the stems depressed, 4 or 5 dm. long, freely branching: leaves from suborbicular to ovate, coarsely but bluntly sinuate-dentate, subcordate or truncate below, pubescent on both faces, 1 to 5 cm. long, 1 to 3 cm. broad, on slender glandular-pilose petioles 1 to 3 cm. long: peduncles short, barely 1 cm. long in fruit: calyx in anthesis 6 or 7 mm. long, sordid-pubescent, with triangular-lanceolate acute lobes: earlier corollas 1.5 cm. broad, sulphur-yellow, with small drab or brownish patches at base: filaments somewhat unequal; anthers yellow and green, narrowly oblong, 3 or 4 mm. long: fruiting calyx broadly short-ovate, glandular-pilose, not conspicuously angled, 1.5 to 2 cm. long. — Apparently in sand (the entire plant coated with fine sand), OAXACA, Boca de Leon, Telixtlahuaca, alt. 2,310 m., Aug. 8, 1895 (*Albert L. Smith*, no. 637). Nearest related, apparently, to *P. rotundata*, Rydberg, of the southwestern United States.

P. saltillensis. Puberulent throughout with fine white stellate hairs: branches slender, terete below, sub-angulate above: leaves elliptic-ovate, coarsely and bluntly sinuate-dentate, the upper unequal and geminate, 3 to 6 cm. long, 2 to 4 cm. wide, unequally subcuneate or rounded at base

to a slender petiole 1.5 to 3.5 cm. long: peduncle filiform, usually curved at tip, in fruit 2 to 3.5 cm. long: calyx in anthesis 6 mm. long, with short narrowly triangular acutish or blunt lobes: corolla 1 to 1.5 cm. broad, sulphur-yellow, with purple patches at base: fruiting calyx ovate, 1.5 to 2 cm. long, obscurely 5-angled, the tips connivent: mature berry orange, edible. — COAHUILA, in shade, Saltillo, Sept. 1898 (*Edw. Palmer*, no. 332).

P. Rydbergii. Perennial (?): stem slender, tough, much branched, finely glandular-puberulent: leaves lanceolate to ovate-lanceolate, subentire or shallowly sinuate-dentate, finely glandular-pubescent on both faces, 0.5 to 1.5 cm. long, 3 to 5 mm. broad, acute at tip, tapering unequally at base to slender petioles about half as long: peduncle filiform, in fruit becoming 1 to 1.5 cm. long: calyx open-campanulate, the lobes not connivent at tip, in anthesis 0.5 cm. long, with ovate-lanceolate blunt lobes: corolla barely 1 cm. in diameter, yellow, with 5 acute lobes: fruiting calyx broadly open-campanulate, 1 cm. long, 5–10-angled, strongly reticulate. — MEXICO, Ymala, Sept. 25–Oct. 8, 1891 (*Edw. Palmer*, no. 1713). Dedicated to Per Axel Rydberg, whose critical studies of this genus have greatly cleared the confusion which prevailed in the American species, and to whose unique section *Crassifoliae* the present species is an addition.

Solanum (Anthoresis) plumense. Shrub with cinereous smoothish bark: young branches finely pulverulent: leaves ovate-lanceolate, long-acuminate, acutish or rounded at the base, 1 to 1.8 dm. long, 4 to 6 cm. wide, entire or slightly undulate, minutely cinereous-stellate on both faces; petioles slender, 2 to 5 cm. long: corymb on a long cinereous-pulverulent peduncle, in fruit 1 to 1.5 dm. broad, many-flowered: calyx 2 mm. high, cinereous-stellate, with 5 ovate-deltoid bluntish lobes: corolla white, stellate-pulverulent without, 0.5 cm. high, 1.5 cm. broad, with ovate-lanceolate lobes: stamens subequal, oblong, truncate, 2 to 2.5 mm. long: fruit subglobose, sparingly pulverulent, 1 cm. in diameter. — OAXACA, about Pluma, alt. 925 to 1,480 m., March 17, 1895 (*E. W. Nelson*, no. 2493).

S. (Polymeris) dejectum. Branching a little above the stout woody root: stems slender, herbaceous, ascending, decumbent at base, branching, cinereous-pilose above with fine stellate hairs: upper leaves geminate, unequal, from subreniform to broadly ovate, rounded or tapering to a bluntish tip, subtruncate or gradually tapering below to a petiole 1 to 3.5 cm. long, finely and closely cinereous-stellate on both faces, more strongly so beneath, entire or slightly undulate, 2 to 5 cm. long:

peduncles slender, in anthesis erect, 0.5 to 1 dm. long, soon strongly dejected: calyx white-stellate, with 10 long linear-subulate divisions: corolla 3 to 4 cm. broad, plicate, 5-angled, violet or violet and white: filaments short, one of them twice or thrice exceeding the others, 5 mm. long; anthers broad-lanceolate, blunt, 5 mm. long: style 10 to 12 mm. long, glabrous: fruit said to be yellow. — DURANGO, rare in crevices of rocks, Iron Mt., &c., near Durango, July, 1896 (*Edw. Palmer*, no. 347): MEXICO, Mount Zacoalco, July 10, 1865 or 1866 (*Hahn*, no. 543); San Juan del Rio, July 14, 1896 (*C. G. Pringle*, no. 7202): GUANAJUATO, in fields, 1895 (*A. Dugès*). Related, apparently, to *S. somniculentum*, Kunze, but differing in its closer whitish pubescence, longer petioles, longer more slender peduncles, and generally blunter leaves.

S. (Polymeris) nocturnum. A woody climber with the habit of *S. lentum*, Cav.: branches glabrous, or minutely stellate-puberulent at tips: leaves solitary or geminate, ovate, 2.5 to 5 cm. long, 2 to 3 cm. wide, with acute or obtuse tips, rounded or acutish below to slender petioles 1 cm. or less in length, subentire, glabrous on both faces, or sparingly puberulent when young: peduncles solitary or in 2's, 1 to 2 cm. long, bearing solitary nocturnal blue flowers: calyx, in anthesis sparingly puberulent, later quite glabrate, a shallow cup with 10 lance-subulate teeth; corolla minutely and sparingly puberulent without, 12 mm. high: berry apparently red, glabrous, 1 cm. in diameter. — GUERRERO, low sandy soil, Acapulco, Jan., 1895 (*Edw. Palmer*, no. 533): OAXACA, river-bed above Tehuantepec, Jan. 10, 1896 (*Ed. Seler*, no. 1625).

S. (Cryptocarpum) macroscolum. Plant with the habit of *S. rostratum*, Dunal: stem puberulent, slightly glandular above, armed with rather scattered yellowish straight stout spines 1 to 1.75 cm. long: leaves very deeply pinnatifid, the segments again cut into rounded lobes, sparingly pilose above or glabrate, armed with long stout spines: calyx hirsute, becoming glabrate, armed with several long (1.5 cm.) slender spines and many shorter finer ones, deeply cut into lanceolate lobes: corolla as in *S. rostratum*: 4 stamens subequal, 8 or 10 mm. long, the other larger, arcuate, 18 mm. long: fruiting calyx, including the persistent lobes, 15 to 18 mm. long. — OAXACA, near the town of Oaxaca, Sept. 19, 1895 (*L. C. Smith*, no. 814), Nov. 18, 1895 (*Ed. Seler*, no. 1394): originally collected by Haenke, presumably between Acapulco and the City of Mexico.

S. (Nycterium) azureum. Stem fruticose, the young branches, with peduncles pedicels and calyx, cinereous with dense but fine stellate pubescence; the branches sparingly beset with remote straight slender

brown spines 7 mm. or less in length: leaves solitary or the upper geminate, thin, elliptic-ovate, 4 to 9 cm. long, 2 to 3.5 cm. broad, deeply sinuate-pinnatifid into 5 or 7 unequal oblong or obovate entire or undulate obtuse lobes; above green and thinly pubescent with appressed-stellate hairs, beneath slightly more pubescent, especially on the prominent sometimes sparingly short-setulose nerves; petioles slender, 1 to 3.5 cm. long, often sparingly setulose: peduncles lateral, 5–10-flowered, becoming 6 or 7 cm. long: calyx campanulate, in the staminate flower unarmed, in the pistillate with slender spines 5 mm. or less in length, the 5 lance-subulate teeth 8 or 9 mm. long: corolla 4 or 5 cm. broad, plicate, stellate-tomentose without, apparently sky-blue, slightly irregular, deeply cut into 5 ovate-lanceolate curved segments: anthers yellow, subsessile, in the staminate flower the two shorter ones 1 to 1.5 cm. long, the three longer 3 to 3.5 cm. long, strongly curved above; in the hermaphrodite flower the two short anthers scarcely 1 cm. long, the three long ones straight, 1.5 cm. long: style 2.5 cm. long, strongly curved above: fruit globose, 1.25 cm. in diameter, in herbarium specimens olive-brown; the fruiting-calyx deeply cleft, excluding the fragile elongated lance-subulate tips, about half the height of the fruit. — SINALOA, Topalobampo, Sept. 15–25, 1897 (*Edw. Palmer*, no. 178). Related to the common *Solanum amazonium*, Ker, and to *S. obtusifolium*, Mart. & Gal. From *S. amazonium* it differs principally in its thin deeper-lobed and greener leaves, its longer stamens and shorter fruiting-calyx. From of *S. obtusifolium* as described it is separated by its larger leaves which are not "cordate-ovate," and its much larger flowers.

Datura villosa. Annual, 1.5 to 3 dm. high: young branches and petioles villous with long white hairs: leaves 0.5 to 1 dm. long, petiolate, ovate, sinuate-angulate or deeply cut, villous above and especially beneath on the veins, becoming glabrate: calyx cylindric, 2.5 to 3.5 cm. long, somewhat villous, with 5 short teeth: corolla narrow, twice exceeding the calyx, pale below, purplish at edge, with 5 short lance-subulate teeth: capsule puberulent, about 5 cm. across, armed with comparatively few coarse and unequal flat prickles. — JALISCO, Bolaños, Sept. 10–19, 1897 (*J. N. Rose*, no. 3680): SAN LUIS POTOSI, in sand near the city of San Luis Potosi, 1876 (*J. G. Schaffner*, no. 706); in the mountains at 1,850 to 2,450 m., 1878 (*Parry & Palmer*, no. 658, in part). — Related to *D. quercifolia*, HBK., with which it has been confused.

CESTRUM ELEGANS, Schlecht., var. **truncata.** Like the species as

represented in Bot. Reg. xxx. t. 43, but with the corolla limb merely short-toothed or subentire, not definitely lobed. — VERA CRUZ, San Miguel del Soldado, alt. 1,850 m., April 20, 1899 (*C. G. Pringle*, no. 7800).

C. fulvescens. Branches stout; cortex yellowish brown, pruinose or glabrate: leaves lanceolate or ovate-lanceolate, short-acuminate, 4 to 7 cm. long, 1 to 2 cm. wide, on slender petioles 1 to 2 cm. long, dark green and minutely puberulent above, yellow-green and puberulent beneath: inflorescences on short (1 dm. or less) leafy fulvous-pubescent branches; the flowers in small axillary clusters or more abundant at the naked tip; pedicels 3 to 7 mm. long, jointed below the very slender neck (3 mm. long) of the calyx: tubular-campanulate calyx broadened above, 1.5 to 2 cm. long, glabrous, conspicuously nerved, with 5 (or 6) unequal deltoid acute ciliate lobes 4 mm. or less in length: corolla 2.5 to 3 cm. long, the yellow tube slender, slightly exceeding the calyx, clavate above and enlarged at the throat; limb of 5 (or 6) elongate-lanceolate strongly involute ascending yellow-brown lobes, short-pubescent especially within. — OAXACA, mountains of Telixtlahuaca, alt. 2,000 m., Apr. 5, 1895 (*L. C. Smith*, no. 343). Apparently a member of the section *Habrothamnus*, but with paler flowers than in any described species of that section.

C. Bourgeauianum. Branches slender, glabrous, covered with a grayish brown cortex: leaves glabrous, entire, oblong-lanceolate to oblong-elliptic, acutish, including the short petiole 4 to 6 cm. long, 1 to 2.5 cm. wide: inflorescence leafy-paniculate, of mostly compound sparingly bracteate flexuous or drooping long-peduncled racemes 4 to 9 cm. long: pedicels slender, 3 to 9 mm. long, gradually thickened to the glabrous campanulate shallowly 5-cleft calyx (in anthesis 4 to 5 mm. long, 2 to 3 mm. broad): corolla yellow, glabrous throughout, 1.7 to 2 cm. long, narrowly funnelform below, gradually broadened at the throat; limb with 5 generally broad-flaring somewhat rounded lobes nearly 0.5 cm. long: mature fruit nearly 1 cm. in diameter; calyx becoming as broad as long. — MEXICO, Valley of Mexico, June 12, 1865 or 1866 (*Bourgeau*, no. 57): OAXACA, Mts. southeast of Miahuatlan, alt. 2,950 to 3,235 m., 1895 (*E. W. Nelson*, no. 2525). This is perhaps *C. pedunculare*, Pavon, but that species is described as having glandular reddish branches, purplish-veined leaves, and acuminate corolla-lobes.

Aster jalapensis. Perennial from slender elongated rootstocks: stems decumbent at base, 1 to 2.5 dm. high, slender, very leafy, pilose in lines: leaves oblanceolate, bluntly and shortly acuminate, glabrous or

minutely puberulent, the upper half coarsely appressed-serrate, the lower half entire and cuneate to a narrow-winged subpetiolar strongly ciliate base, including the subpetiolar portion 3 to 5 cm. long, 0.5 to 1 cm. wide; the upper smaller: peduncles slender, bracteate, elongate, 2 to 6 cm. long, bearing 1 or 2 heads about 1 cm. broad: bracts of involucre 3-seriate, linear-oblong, the inner 6 mm. long, the outer much shorter, slightly ciliate on the margins, with short bluntish herbaceous appressed tips: rays white: achene pubescent. — VERA CRUZ, wet ledges, Barranca de Chavarrillo, alt. 920 m., Apr. 24, 1899 (*C. G. Pringle*, no. 8118). Somewhat resembling *A. bullatus*, Klatt, but a lower more slender plant with shorter broader leaves, broader involucral bracts, and more slender peduncles.

Encelia Pringlei. Stem subterete, scabrous-puberulent: leaves oblong or ovate-lanceolate, acuminate, the lower rather abruptly narrowed below the middle into an oblong portion which is somewhat auriculate at base; the larger 1.2 to 1.4 dm. long, 4 to 6 cm. wide, above tuberculate-scabrous; beneath scabrous, glandular-dotted, and somewhat villous on the nerves; petioles very short: inflorescence terminal, corymbose, 1 to 1.5 dm. across: heads 1 to 1.5 cm. broad, excluding the rays 1.5 cm. long: bracts of involucre 2–3-seriate, the outer successively shorter, linear-oblong, bluntish, appressed-pubescent and somewhat glutinous: rays 8 or 9, ovate-oblong, 1 cm. long, orange-yellow: achene 6 mm. long, silvery-silky; the pappus of two lanceolate awn-tipped pales 4 or 5 mm. long, and two shorter broader somewhat lacerate ones. — HIDALGO, hillsides above Pachuca, alt. 2,770 m., Sept. 14, 1899 (*C. G. Pringle*, no. 8248). With remarkably paleaceous pappus for an *Encelia*, but apparently very closely related to *E. glutinosa*, Rob. & Greenman.

PUBLICATIONS

OF THE

AMERICAN ACADEMY OF ARTS AND SCIENCES.

MEMOIRS. OLD SERIES, Vols. I.–IV.; NEW SERIES, Vols. I.–XII. 16 volumes, $10 each. Half volumes, $5 each. 25% discount to booksellers; 50% to members.

Vol. X.	Part II. *bis*	. . . . . .	$1.75
" XI.	" I.	. . . .	2.00
" XI.	" II. No. I.	. . . . . .	3.00
" XI.	" III. " II.–III.	. . .	1.00
" XI.	" IV. " IV.	. . . . . .	1.00
" XI.	" IV. " V.	. . . . . .	.75
" XI.	" V. " VI.	. . . . . .	.25
" XI.	" VI. " VII.	. . . . .	2.00
" XII.	No. I.	. . . .	1.50
" XII.	" II.	. . . .	2.00
" XII.	" III.	. . . .	6.00
" XII.	" IV.	. . . .	1.25

PROCEEDINGS. Vols. I.–XXXIV., $5 each. 25% discount to booksellers; 50% discount to members.

Complete sets of the MEMOIRS, 15 vols., for $112.50, to members, $60; of the PROCEEDINGS, 34 vols. for $129, to members, $68.

Proceedings of the American Academy of Arts and Sciences.

VOL. XXXV. No. 26. — JUNE, 1900.

ON THE SINGULAR TRANSFORMATIONS OF GROUPS GENERATED BY INFINITESIMAL TRANSFORMATIONS.

BY HENRY TABER.

PROCEEDINGS.

Nine hundred and eighth Meeting.

MAY 10, 1899. — ANNUAL MEETING.

VICE-PRESIDENT HYATT in the chair.

In the absence of the Recording Secretary, William E. Story was elected Recording Secretary *pro tempore.*

The Chair announced the death of Alvan Wentworth Chapman, of Appalachicola, Associate Fellow in Class II., Section 2.

The Corresponding Secretary read letters from Felipe Valle, announcing his appointment as Director of the Astronomical Observatory of Tacubaya; from Angel Anguiano, announcing his appointment as Director of the Mexican Geodetic Commission; from the Geographical Society of Madrid, announcing the death of its President, Francisco Coello de Portugal y Quesada; from H. P. Talbot and O. F. Wadsworth, accepting Fellowship in the Academy; from Charles D. Walcott, acknowledging his election as Associate Fellow; and from Oliver Heaviside, acknowledging his election as Foreign Honorary Member. A letter from the University of Cambridge inviting the Academy to appoint a delegate to the jubilee of Sir George Gabriel Stokes, Bart., in June, 1899, was read, and, on motion of Charles R. Cross, it was

Voted, That the President and Corresponding Secretary send a letter of congratulation to Sir George G. Stokes.

A letter from the Commission on Atomic Weights of the German Chemical Society, inviting "Chemical Societies and similar Institutions of all countries to assist in the formation of an International Commission," was read, and, on motion of the Corresponding Secretary, it was

Voted, That a committee of three be appointed to represent the Academy in the International Commission on Atomic Weights. The Chair appointed Theodore W. Richards, Wolcott Gibbs, and Ira Remsen members of this committee.

The Corresponding Secretary announced that the Committee to select a delegate to the International Congress of Orientalists at Rome in October next had appointed Charles Rockwell Lanman of Cambridge, and that he had accepted.

The Corresponding Secretary read the report of the Council.*

The Treasurer presented his annual report of which the following is an abstract: —

General Fund.

Receipts.

Balance, April 30, 1898			$3,481.95
Assessments	$990.00		
Sale of publications	48.52	$1,038.52	
Income from investments		4,850.63	
Return of bank tax		45.00	
Donations		105.00	6,039.15
			$9,521.10

Expenditures.

General expenses	$2,023.69	
Library expenses	1,559.70	
Publishing expenses	2,071.95	$5,655.34
Investments		3,833.15
Balance, April 29, 1899		32.61
		$9,521.10

Rumford Fund.

Receipts.

Balance, April 30, 1898	$1,778.44
Income	2,266.03
Return of bank tax	93.53
Return of Investment	1,034.99
	$5,172.99

* See Proceedings, XXXIV. p. 639.

Expenditures.

Books	$57.01	
Publishing	790.88	
Investigations	400.00	
Rent	10.00	$1,257.89
Balance, April 29, 1899		3,915.10
		$5,172.99

WARREN FUND.

Receipts.

Balance, April 30, 1898	$925.95
Income	853.48
	$1,779.43

Expenditures.

Investigations	$630.00
Balance, April 29, 1899	1,149.43
	$1,779.43

BUILDING FUND.

Receipts.

Balance, April 30, 1898	$1,268.14
Income	504.83
	$1,772.97

Expenditures.

Investment	$1,466.94
Balance, April 29, 1899	306.03
	$1,772.97

The annual report of the Librarian was presented and showed that 3284 books and pamphlets had been added to the Library during the year, of which 2432 were obtained by gift and exchange and 852 purchased, and 317 volumes were bound at an expense of $419.70. The total expenditure for books, periodicals, and binding amounted to $1004.17. There were borrowed 235 books by 30 persons, of whom 18 were Fellows of the Academy.

The following reports were also presented: —

Report of the Rumford Committee.

Boston, May 10, 1899.

During the past year the Rumford Committee has made the following appropriations from the fund of $1000 placed at its disposition at the last Annual Meeting, for the furtherance of researches in light and heat.

To Professor Theodore W. Richards of Harvard University, $200 for the construction of a micro-kinetoscope, the immediate application of which is to be the study of the birth and growth of crystals.

To Professor W. C. Sabine of Harvard University, $200 for the continuation of his researches on the wave-lengths of ultra-violet radiations.

To Professor Henry Crew of the Northwestern University, a sum not exceeding $200 for the continuation of his researches upon the spectrum of the electric arc.

To Professor Arthur G. Webster of Clark University, $200 for a research upon the distribution of energy in various spectra by means of the Michelson interferometer and the radiometer.

At a meeting held on April 12, 1899, it was voted that the Committee recommend to the Academy that the volumes necessary to complete the set of the "Fortschritte der Physik" in the library of the Academy, be purchased from the Rumford Fund.

At the same meeting it was also voted that the Committee recommend to the Academy the appropriation of one hundred and twenty dollars from the Rumford Fund for the purchase and binding of the usual periodicals of the current fiscal year.

At a meeting held on May 3, 1899, it was voted that the Academy be asked to make the usual appropriation of $1000, at the Annual Meeting, to be expended at the discretion of the Committee in furtherance of research.

At the April meeting of the Committee it was voted for the first time, "that the Rumford Committee recommend to the Academy the award of the Rumford Medal to Mr. Charles F. Brush, for the Practical Development of Electric Arc Lighting." At the May meeting of the Committee the same resolution was voted for the second time.

In order to ascertain the stage of advancement of the various researches in aid of which appropriations have been granted from the Rumford Fund, a request for information was sent to such grantees as were understood not to have made a final report, together with the following extracts from the records of the Committee: —

Nov. 10, 1897. "It was voted that, in future, recipients of grants for

investigations be requested to make a report annually as to the state of the work for which the grant was made."

June 8, 1898. "It was voted that in the judgment of the Committee, persons carrying on researches with the aid of the Rumford Fund should submit to the Academy an account of their researches not less complete than that published elsewhere. These researches may be published in any place or form, with the proviso that due recognition be made of the grant, and the presentation of the paper to the Academy."

In answer to this request, reports have been received of which the following are summaries: —

Professor Henry Crew has published a paper "On the Sources of Luminosity in the Electric Arc" in the Proceedings of the Academy for June, 1898. He expects to continue the prosecution of his research during the coming summer with the aid of the further appropriation made by the Rumford Committee for that purpose.

Professor B. O. Peirce reports that a continuation of his work upon the thermal conductivity of poor conductors is in progress, the substance vulcanite being at present a particular subject of study. An extended paper "On Thermal Conductivities of Certain Poor Conductors" was published in the Proceedings of the Academy for August, 1898.

Professor E. H. Hall is pursuing his studies upon the thermal conductivity of wrought iron, having published in the Proceedings for February, 1899, a paper "On the Thermal Conductivity of Cast Iron."

Professor Edward L. Nichols reports that his research upon the radiation from carbon at high temperatures is making good progress. The study of the acetylene flame as a standard of light, the calibration of thermo-elements, and the application of the platinum-rhodium thermo-element to the determination of the actual temperature of the carbon, have occupied much time. Measurements with the spectro-photometer are now in progress upon the visible radiations from carbon rods as compared with those of like character with the acetylene flame. A study of the distribution of energy in the spectrum of the acetylene flame and in that of incandescent carbon will follow.

Professor W. C. Sabine says with regard to his investigation upon the study of very short light waves: "In order to explain the advance which he has made [Mr. Theodore Lyman, who has made the actual measurements], it will be necessary to refer to the work of Schumann. This work was done with a fluorite prism, and wave lengths were found by extrapolation, the statement being made that speculum metal would not reflect the shorter waves. Mr. Lyman has been using a concave grating

with success, and has got as low as wave length 900 tenth-meters, Schumann's estimated limit being 1000. The latter worked entirely with the spectra of gases, and stated that he could not go below wave length 1600 for metals."

Professor George E. Hale states that the spectro-heliograph, in the construction of which he has been aided by a grant from the Rumford Fund, is approaching completion. He writes that "devices have been introduced whereby photographs of prominences or faculae can be taken simultaneously in two different lines of the spectrum. In the case of eruptive prominences the comparison of photographs made in this way may prove to be instructive."

Professor Theodore W. Richards states that he has begun his investigation of the birth and growth of crystals as studied by the micro-kinetoscope, and has already obtained various excellent photographs illustrating these phenomena, which also give promise of interesting results as to the rate of growth of different crystals.

CHARLES R. CROSS, *Chairman.*

REPORT OF THE C. M. WARREN COMMITTEE.

10 May, 1899.

At the last Annual Meeting of the Academy the sum of $600 from the income of the Warren Fund, was granted to Professor C. F. Mabery, of Cleveland, Ohio, in furtherance of his researches on petroleum. Several papers explanatory of Professor Mabery's results have been published during the year; and it is well understood that his work is being prosecuted all the while with ardor and success.

A research by Professor F. C. Phillips, of Allegheny City, in aid of which a grant of $200 was made in 1896, has been in so far completed that an account of it was published, in November last, in the Proceedings of the Academy, under the title "On Fluctuations in the Composition of Natural Gas."

A grant in the sum of $200 made to Professor H. O. Hofman, of Boston, in 1897, and supplemented in 1898 by an additional grant of $30, has also borne good fruit. Professor Hofman's subject was "The Fusibility of Slags." He has explained to me that interesting and important results have been obtained, which he intends to publish in the near future.

F. H. STORER, *Chairman.*

Report of the Committee of Publication.

Boston, May 10, 1899.

The Publishing Committee begs leave to report that there have been issued during the last academic year ten numbers of Vol. XXXIII. and the first twenty numbers of Vol. XXXIV. of the Proceedings, aggregating 796 pages and 17 plates; besides one number of Vol. XII. of the Memoirs containing 36 pages and 7 plates. Five numbers of the Proceedings have been printed at the cost of the Rumford Fund. The expenditure for the remaining publications was $2334.14. The appropriation from the General Fund was $2500 and the sales $48.52, making a sum available for publication of $2548.52, and leaving therefore an unexpended balance of $214.38. The Academy has never before published so many pages in a single year.

Samuel H. Scudder, *Chairman*.

On the recommendation of the Committee of Finance, it was

Voted, To make the following appropriations from the income of the General Fund for the ensuing year: —

For general expenses	$2000
For the library	1500
For publishing	2400

Voted, That the assessment for the ensuing year be five dollars.

Voted, That the Treasurer be authorized to pay from the funds of the Academy any bills approved by the Librarian incurred on account of the expense of moving the library.

On the recommendation of the Rumford Committee, it was

Voted, That the sum of one thousand dollars ($1000) from the income of the Rumford Fund be placed at the disposal of the Rumford Committee to be expended in aid of investigations on Light and Heat, payments to be made on the order of the Chairman of the Committee.

Voted, That the volumes necessary to complete the set of the "Fortschritte der Physik" in the library be purchased at the expense of the income of the Rumford Fund; also, that one hundred and twenty dollars ($120) be appropriated from the

income of the Rumford Fund for the purchase and binding of periodicals.

On the recommendation of the C. M. Warren Committee, it was

Voted, That the sum of six hundred dollars ($600) from the income of the Warren Fund be granted to Charles F. Mabery, of Cleveland, Ohio, in aid of his researches on the chemistry of petroleum.

In accordance with the recommendation of the Rumford Committee, it was

Voted, To award the Rumford Premium to Charles F. Brush for the practical development of electric arc lighting.

The annual election resulted in the choice of the following officers and committees: —

ALEXANDER AGASSIZ, *President.*
JOHN TROWBRIDGE, *Vice-President for Class I.*
ALPHEUS HYATT, *Vice-President for Class II.*
AUGUSTUS LOWELL, *Vice-President for Class III.*
SAMUEL H. SCUDDER, *Corresponding Secretary.*
WILLIAM WATSON, *Recording Secretary.*
FRANCIS BLAKE, *Treasurer.*
A. LAWRENCE ROTCH, *Librarian.*

Councillors.

HENRY TABER,
THEODORE W. RICHARDS,
HARRY M. GOODWIN, } of Class I.

BENJAMIN L. ROBINSON,
WILLIAM T. COUNCILMAN,
JOHN E. WOLFF, } of Class II.

BARRETT WENDELL,
EDWARD ROBINSON,
JAMES B. AMES, } of Class III.

Member of the Committee of Finance.

AUGUSTUS LOWELL.

Rumford Committee.

ERASMUS D. LEAVITT, AMOS E. DOLBEAR,
EDWARD C. PICKERING, ARTHUR G. WEBSTER,
CHARLES R. CROSS, THEODORE W. RICHARDS,
THOMAS C. MENDENHALL.

C. M. Warren Committee.

FRANCIS H. STORER, HENRY B. HILL,
CHARLES L. JACKSON, LEONARD P. KINNICUTT,
SAMUEL CABOT, ARTHUR M. COMEY,
ROBERT H. RICHARDS.

The Chair appointed the following standing committees: —

Committee of Publication.

SAMUEL H. SCUDDER, SETH C. CHANDLER,
CRAWFORD H. TOY.

Committee on the Library.

A. LAWRENCE ROTCH, HENRY W. HAYNES,
SAMUEL HENSHAW.

Auditing Committee.

JOHN C. ROPES, ELIOT C. CLARKE.

The following gentlemen were elected members of the Academy: —

William Elwood Byerly, of Cambridge, to be a Resident Fellow in Class I., Section 1 (Mathematics and Astronomy).

William Henry Pickering, of Cambridge, to be a Resident Fellow in Class I., Section 1.

Henry Lefavour, of Williamstown, to be a Resident Fellow in Class I., Section 2 (Physics).

Charles Russell, Baron Russell of Killowen, of Tadworth, to be a Foreign Honorary Member in Class III., Section 1 (Philosophy and Jurisprudence).

The following papers were presented by title: —
On the Thermal Conductivity of Vulcanite. By B. O. Peirce.
Ferrous Iodide. By C. Loring Jackson and Ira H. Derby.

Nine hundred and ninth Meeting.

JUNE 14, 1899.

The PRESIDENT in the chair.

The Corresponding Secretary read letters from W. E. Byerly and W. H. Pickering, accepting Fellowship, and from Lord Russell of Killowen, acknowledging his election as Foreign Honorary Member. Letters from Marion T. Hosmer, soliciting a subscription on behalf of the Rumford Historical Society, and from the University of Pennsylvania, the American Philosophical Society, and other Philadelphia Societies, inviting attendance at the presentation of the Franklin statue, were referred to the Corresponding Secretary.

The Chair announced the death of Francis Minot, Resident Fellow in Class II., Section 4, and of Manning Ferguson Force, Associate Fellow in Class III., Section 3.

The Rumford Medal awarded to James Edward Keeler at the annual meeting of 1898 was presented, Edward C. Pickering acting as Professor Keeler's proxy.

The President spoke of the proposed exploring expedition to the mid-Pacific under his direction, the United States Commission of Fish and Fisheries having placed the Albatross at his disposal. The vessel will be thoroughly equipped with the newest apparatus for deep-sea investigations, and special appliances will be constructed for use in very deep water. The expedition will leave San Francisco about the middle of August for Tahiti, in the Society Islands, which will be the headquarters during the six or eight weeks required for exploration of the Paumoto Islands. Afterwards a week or ten days will be spent among the Tonga or Friendly Islands, and the expedition will then proceed to the Fiji Islands, where a short stay will be made. After visiting some of the Ellis and Gilbert Islands, six or seven weeks will be devoted to the exploration of the Mar-

shall Islands. Between these islands and the Hawaiian Islands, and between the latter and San Francisco, a distance of four thousand miles, a line of deep-sea dredgings will be run, deep-sea tow-nets being used while the dredging is going on. The Albatross is expected to return to the United States in April next.

The following papers were presented by title: —

The Development and Application of a General Equation for Free Energy and Physico-chemical Equilibrium. By Gilbert Newton Lewis. Presented by T. W. Richards.

The Electro-chemical Equivalents of Copper and Silver. By T. W. Richards, E. Collins, and G. W. Heimrod.

A Revision of the Atomic Weight of Calcium. By T. W. Richards.

Short Studies of North American Tryxalinae. By Samuel H. Scudder.

The Recording Secretary read the agreement with the Massachusetts Historical Society in regard to quarters for the Academy in the new building of the Society. Remarks on this subject were made by the President and Augustus Lowell.

Nine hundred and tenth Meeting.

OCTOBER 11, 1899. — STATED MEETING.

The Academy met at Ellis Hall.

VICE-PRESIDENT HYATT in the chair.

The Corresponding Secretary read letters from Henry Lefavour, accepting Fellowship in the Academy; from the Royal Academy of Sciences of Turin, announcing the death of Professor Cesare Nani; from the National Society of Horticulture of France, announcing the death of its first Vice-President, Henri Lévêque de Vilmorin; from the Students' Union at the Polytechnic School at Zurich, inviting attendance at the twenty-fifth jubilee of Professor A. Heim; from Captain Constantin Edler von Pott, announcing his appointment as Director of the Hydrographic Bureau of the Imperial and Royal Navy at Pola; and from Charles R. Lanman, reporting his inability

to represent the Academy at the International Congress of Orientalists. A letter from the Secretary of the organizing committee of the International Congress of Physics at Paris in 1900, enclosing a prospectus and requesting that it be brought to the notice of members, was referred to the members of the Council from Class I.

The Corresponding Secretary reported that, in response to letters of invitation received during the summer, the President had appointed George P. Fisher, Associate Fellow, as a delegate to the celebration of the one hundredth anniversary of the Connecticut Academy of Arts and Sciences, and Vice-President Trowbridge had appointed T. C. Mendenhall, Resident Fellow, to represent the Academy at the celebration of the seventy-fifth anniversary of the founding of the Franklin Institute.

The Chair announced the death of John Harrison Blake, of Boston, Resident Fellow in Class I., Section 2; and of Robert Wilhelm Bunsen, of Heidelberg, Foreign Honorary Member in Class I., Section 3.

On the motion of the Corresponding Secretary, a quorum for business not being present, it was

Voted, To meet on adjournment on the second Wednesday in November.

Arthur G. Webster read and explained a paper presented by A. A. Michelson on the Echelon Spectroscope.

The following papers were read by title: —

Peripheral Distribution of the Cranial Nerves of *Spelerpes bilineatus*. By Mary A. Bowers. Presented by E. L. Mark.

Note on the Finite Continuous Groups of the Plane. By F. B. Williams. Presented by Henry Taber.

Two Genera of North American Decticinae. By S. H. Scudder.

Nine hundred and eleventh Meeting.

NOVEMBER 8, 1899. — ADJOURNED STATED MEETING.

In the absence of the regular presiding officers, HENRY P. BOWDITCH was chosen President *pro tempore*.

The Chair announced the death of John Codman Ropes, Resident Fellow in Class III., Section 3.

Samuel H. Scudder tendered his resignation as Corresponding Secretary, to take effect in January, and it was accepted.

The Chair appointed from the next retiring Councillors

THEODORE W. RICHARDS, of Class I.,
BENJAMIN L. ROBINSON, of Class II.,
BARRETT WENDELL, of Class III.,

a committee to nominate a candidate for the office of Corresponding Secretary.

On the motion of the chairman of the C. M. Warren Committee, it was

Voted, To grant permission to H. O. Hofman to publish in the Transactions of the American Institute of Mining Engineers or elsewhere the results of his research, for which aid was granted by the Academy from the C. M. Warren Fund.

On the motion of the Librarian, it was

Voted, To authorize the expenditure of a sum not exceeding two hundred dollars ($200) for furniture for the Library.

The following gentlemen were elected members of the Academy: —

Maxime Bôcher, of Cambridge, to be a Resident Fellow in Class I., Section 1 (Mathematics and Astronomy).

William Fogg Osgood, of Cambridge, to be a Resident Fellow in Class I., Section 1.

John Singer Sargent, of London, to be an Associate Fellow in Class III., Section 4 (Literature and the Fine Arts).

Sir Benjamin Baker, of London, to be a Foreign Honorary Member in Class I., Section 4 (Technology and Engineering), in place of the late Sir Henry Bessemer.

Rudyard Kipling, of Rottingdean, to be a Foreign Honorary Member in Class III., Section 4 (Literature and the Fine Arts).

Arthur G. Webster described Maxwell's electric top and exhibited it in operation.

The following papers were presented by title: —

Contributions from the Cryptogamic Laboratory of Harvard

University, XLI. Preliminary Diagnoses of New Species of Laboulbeniaceae. — I. By Roland Thaxter.

Note on the Chief Theorem of Lie's Theory of Continuous Groups. By S. E. Slocum. Presented by Henry Taber.

Nine hundred and twelfth Meeting.

DECEMBER 13, 1899.

The CORRESPONDING SECRETARY in the chair.

Letters were received from the Royal Academy of Sciences of Turin, announcing the death of Domenico Perrero; from the International Congress of Ethnographical Sciences, enclosing programmes and an invitation to attend its meetings at Paris during the summer of 1900; from Maxime Bôcher, John S. Sargent, and Rudyard Kipling, accepting membership.

A letter was read from the Royal Prussian Academy of Sciences of Berlin, announcing the celebration of the two hundredth anniversary of its foundation on the 19th and 20th of March, 1900, and inviting the American Academy to send delegates. It was accordingly

Voted, To appoint John Williams White and John Eliot Wolff, delegates to this celebration.

The chair announced the death of Epes Sargent Dixwell, Resident Fellow in Class III., Section 2.

The following papers were read: —

Experimental and Statistical Studies on the Influence of Cold on the Bacillus of Typhoid Fever and its Distribution; with special Reference to Ice Supply and the Public Health. By William T. Sedgwick and Charles-Edward A. Winslow.

The Electrical Resistance of the Human Body. By William L. Hooper.

The following papers were presented by title: —

A Revision of the Atomic Weight of Iron. By T. W. Richards and C. P. Baxter.

Note on the Constitution of Diparabrombenzylcyanamide. By C. Loring Jackson and R. W. Fuller.

On Certain Colored Substances Derived from Nitro Compounds. Third paper. By C. Loring Jackson and F. H. Gazzolo.

Certain Derivatives of Metadibrombenzyl. By C. Loring Jackson and W. P. Cohoe.

Nine hundred and thirteenth Meeting.

JANUARY 10, 1900. — STATED MEETING.

VICE-PRESIDENT HYATT in the chair.

The Corresponding Secretary read letters from Sir B. Baker and William Fogg Osgood, acknowledging election. He also read circulars from the Royal Academy of Sciences of Turin, announcing the terms of award of the Vallauri prizes, and from the International Congress of Comparative History and the International Congress of Horticulture, Arboriculture, and Pomology, enclosing programmes.

A letter was received from Seabury C. Mastick, Secretary of the committee on the modification of the Federal Legacy Tax, enclosing a petition setting forth the desired modification of the law. On the motion of William E. Story, it was

Voted, That the Acting President be instructed to sign this petition on behalf of the Academy.

The Chair announced the following deaths: —

Sir John William Dawson, of Montreal, Associate Fellow in Class II., Section I.

William Alexander Hammond, of Washington, Associate Fellow in Class II., Section 4.

Sir James Paget, Bart., of London, Foreign Honorary Member in Class II., Section 4.

The vacancy occasioned by the resignation of Samuel H. Scudder was filled by the election of

WILLIAM M. DAVIS, *Corresponding Secretary*.

On the motion of Augustus Lowell, it was

Voted, That the thanks of the Academy be tendered to

Samuel Hubbard Scudder for his faithful and efficient services as Corresponding Secretary.

The following gentlemen were elected members of the Academy: —

James Mason Crafts, of Boston, as Resident Fellow in Class I., Section 3 (Chemistry).

Joseph Hodges Choate, of New York, as Associate Fellow in Class III., Section 1 (Philosophy and Jurisprudence), in place of the late Thomas McIntyre Cooley.

William Wirt Howe, of New Orleans, as Associate Fellow in Class III., Section 1.

William Mitchell, of Saint Paul, as Associate Fellow in Class III., Section 1, in place of the late Ezekiel Gilman Robinson.

Sir George Otto Trevelyan, Bart., of London, as Foreign Honorary Member in Class III., Section 3 (Political Economy and History).

The vacancies in the Auditing Committee occasioned by the resignation of Eliot C. Clarke and the death of John C. Ropes were filled by the appointment of the following

Auditing Committee:

HENRY G. DENNY, WILLIAM L. RICHARDSON.

On the recommendation of the Rumford Committee, it was

Voted, That the Academy appropriate one hundred dollars ($100) to Theodore W. Richards for the prosecution of a research on the transition point of crystallized salts.

Voted, That the Treasurer be authorized to make arrangements for the sale to the public of the Life and Works of Count Rumford.

John S. Kingsley read a paper entitled "The Ancestry of the Mammalia."

The following papers were presented by title: —

Contributions from the Gray Herbarium of Harvard University. New Series. — No. XVIII.

I. New Species and Varieties of Mexican Plants. By J. M. Greenman.

II. Synopses of the Genera Jaegeria and Russelia. By B. L. Robinson.
III. New Dioscoreas from Mexico. By E. B. Uline.
IV. New Phanerogams chiefly Gamopetalae from Mexico and Central America. By B. L. Robinson.

Nine hundred and fourteenth Meeting.

February 14, 1900.

In the absence of the regular presiding officers, SAMUEL H. SCUDDER acted as President *pro tempore.*

The chair announced the death of the following Foreign Honorary Members: —

James Martineau, of London, Class III., Section 1.

Carl Friedrich Rammelsberg, of Berlin, Class II., Section 1.

John Ruskin, of Coniston, Class III., Section 4.

The following letters were received: from Mathilde Rammelsberg, announcing the death of Carl Friedrich Rammelsberg, Foreign Honorary Member of the Academy in Class II., Section 1; from W. M. Davis, accepting his election as Corresponding Secretary; from John Williams White, accepting his appointment as Delegate to the celebration of the 200th anniversary of the foundation of the Royal Prussian Academy of Sciences.

The following papers were presented by title: —

The Metamerism of the Hirudinea. By W. E. Castle. Presented by E. L. Mark.

The Freshwater Tertiary Formations of the Rocky Mountain region. By W. M. Davis.

On the Determination of Sulphuric Acid in the Presence of Iron: a Note on Solid Solutions. By Theodore William Richards.

The Species of the Orthopteran Genus Derotmema. By Samuel H. Scudder.

Crawford H. Toy gave an informal account of a new theory of totemism.

Nine hundred and fifteenth Meeting.

March 14, 1900 — STATED MEETING.

The Academy met, by invitation of John E. Hudson, at the Algonquin Club.

VICE-PRESIDENT TROWBRIDGE in the chair.

The Corresponding Secretary read letters from Joseph H. Choate and Sir G. O. Trevelyan acknowledging their election into the Academy. He also exhibited a bronze copy of the medal struck in honor of Sir George G. Stokes's Jubilee in 1899, presented to the Academy by the University of Cambridge.

On motion of the Recording Secretary, it was

Voted, To meet, on adjournment, on the second Wednesday in April.

The following gentlemen were elected members of the Academy: —

Arlo Bates, of Boston, to be a Resident Fellow in Class III., Section 4 (Literature and the Fine Arts).

Liberty Hyde Bailey, of Ithaca, to be an Associate Fellow in Class II., Section 2 (Botany), in place of the late Alvan Wentworth Chapman.

Friedrich Kohlrausch, of Berlin, to be a Foreign Honorary Member in Class I., Section 2 (Physics).

The Chair appointed the following Councillors to act as Nominating Committee: —

THEODORE W. RICHARDS, of Class I.,
BENJAMIN L. ROBINSON, of Class II.,
BARRETT WENDELL, of Class III.

At the request of the Chair, Charles R. Cross, Chairman of the Rumford Committee, stated the grounds for the award of the Rumford Premium to Charles F. Brush for his researches in electric arc lighting.

The Acting President then presented the medal to Mr. Brush, who, in response, gave an account of his early experiments in electricity.

Elihu Thomson described new electric apparatus for high

potentials, and exhibited an improved form of his dynamo-electric machine.

The following papers were presented by title: —

View of the Carboniferous Fauna of the Narragansett Basin. By A. S. Packard.

Contributions from the Gray Herbarium of Harvard University. New Series. — No. XIX. By M. L. Fernald. Presented by B. L. Robinson.

I. Synopsis of the Mexican and Central American Species of Salvia.

II. Revision of the Mexican and Central American Solanums of the Subsection Torvaria.

III. Some Undescribed Mexican Phanerogams, chiefly Labiatae and Solanaceae.

Historical Notes relating to Musical Pitch in the United States. By Charles R. Cross.

Nine hundred and sixteenth Meeting.

APRIL 11, 1900. — ADJOURNED STATED MEETING.

The PRESIDENT in the chair.

The Chair announced the following deaths: —

Silas Whitcomb Holman, Resident Fellow in Class I., Section 2.

Edward John Phelps, Associate Fellow in Class III., Section 3.

The Rumford Committee made a preliminary announcement that it would recommend, at the next annual meeting, the award of the Rumford Premium to Carl Barus, of Providence.

The following motion was offered by W. E. Story: —

That a committee consisting of the President and two others selected by him be appointed to consider the propriety of amending the first section of Chapter I. of the Statutes, with reference to the classification of the Fellows and Foreign Honorary Members.

The following recommendation was offered by the Rumford Committee: —

The Rumford Committee recommends that the Academy

appropriate the sum of two hundred and fifty dollars ($250) from the income of the Rumford Fund to Arthur L. Clark, of Worcester, to aid in the prosecution of researches on the properties of vapors near the critical point.

W. M. Davis read a paper entitled "The Freshwater Tertiary Formations of the Rocky Mountain Region."

The following papers were presented by title: —

Contributions from the Cryptogamic Laboratory of Harvard University XLII.: Preliminary Diagnoses of New Species of Laboulbeniaceæ. — II. By Roland Thaxter.

The Driving Energy of Physico-chemical Reaction and its Temperature Coefficient. By Theodore W. Richards.

Supplementary Note on the Chief Theorem of Lie's Theory of Finite Continuous Groups. By Stephen Elmer Slocum. Presented by Henry Taber.

On the Singular Transformations of Groups generated by Infinitesimal Transformations. By Henry Taber.

A TABLE OF ATOMIC WEIGHTS

OF SEVENTY-FOUR ELEMENTS.

Compiled in April, 1900, from the most Recent Data.

BY THEODORE WILLIAM RICHARDS.

Name.	Symbol.	Atomic Weight.	Name.	Symbol.	Atomic Weight.
Aluminium . .	Al	27.1	Molybdenum .	Mo	96.0
Antimony . . .	Sb	120.0	Neodymium . .	Nd	143.6
Argon	A	39.9 ?	Nickel	Ni	58.70
Arsenic . . .	As	75.0	Niobium . . .	Nb = Cb	94.
Barium . . .	Ba	137.43	Nitrogen . . .	N	14.04
Beryllium . . .	Be = Gl	9.1	Osmium . . .	Os	190.8
Bismuth . . .	Bi	208.	Oxygen (standard)	O	16.000
Boron	B	11.0	Palladium . . .	Pd	106.5
Bromine . . .	Br	79.955	Phosphorus . .	P	31.0
Cadmium . . .	Cd	112.3	Platinum . . .	Pt	195.2
Cæsium . . .	Cs	132.9	Potassium . . .	K	39.14
Calcium . . .	Ca	40.1	Praseodymium .	Pr	140.5
Carbon	C	12.001	Rhodium . . .	Rh	103.0
Cerium . . .	Ce	140.	Rubidium . . .	Rb	85.44
Chlorine . . .	Cl	35.455	Ruthenium . .	Ru	101.7
Chromium . .	Cr	52.14	Samarium ? . .	Sm	150.
Cobalt	Co	59.00	Scandium . . .	Sc	44.
Columbium . .	Cb = Nb	94.	Selenium . . .	Se	79.2
Copper	Cu	63.60	Silicon	Si	28.4
"Didymium" .	Nd + Pr	142±	Silver	Ag	107.93
Erbium . . .	Er	166.	Sodium . . .	Na	23.05
Fluorine . . .	F	19.05	Strontium . . .	Sr	87.68
Gadolinium . .	Gd	156. ?	Sulphur . . .	S	32.065
Gallium . . .	Ga	70.0	Tantalum . . .	Ta	183.
Germanium . .	Ge	72.5	Tellurium . . .	Te	127.5 ?
Glucinum . . .	Gl = Be	9.1	Terbium ? . . .	Tb	160.
Gold	Au	197.3	Thallium . . .	Tl	204.15
Helium . . .	He	4.0 ?	Thorium . . .	Th	233.
Hydrogen . . .	H	1.0075	Thulium ? . . .	Tu	170. ?
Indium	In	114.	Tin	Sn	119.0
Iodine	I	126.85	Titanium . . .	Ti	48.17
Iridium . . .	Ir	193.0	Tungsten . . .	W	184.
Iron	Fe	55.9	Uranium . . .	U	240.
Lanthanum . .	La	138.5	Vanadium . .	V	51.4
Lead	Pb	206.92	Ytterbium . .	Yb	173.
Lithium . . .	Li	7.03	Yttrium . . .	Yt	89.0
Magnesium . .	Mg	24.36	Zinc	Zn	65.40
Manganese . .	Mn	55.02	Zirconium . .	Zr	90.5
Mercury . . .	Hg	200.0			

AMERICAN ACADEMY OF ARTS AND SCIENCES.

REPORT OF THE COUNCIL. — PRESENTED MAY 9, 1900.

BIOGRAPHICAL NOTICES.

REPORT OF THE COUNCIL.

THE Academy has lost nineteen members by death since the annual meeting of May 10, 1899, as follows: Six Resident Fellows, — John Harrison Blake, Epes Sargent Dixwell, Charles Franklin Dunbar, Silas Whitcomb Holman, Francis Minot, John Codman Ropes; eight Associate Fellows, — Albert Nicholas Arnold, Frederic Edwin Church, Sir John William Dawson, Manning Ferguson Force, Daniel Raynes Goodwin, William Alexander Hammond, Edward John Phelps, George Clinton Swallow; and five Foreign Honorary Members, — Robert Wilhelm Bunsen, James Martineau, Sir James Paget, Carl Friedrich Rammelsberg, and John Ruskin.

EPES SARGENT DIXWELL.

EPES SARGENT DIXWELL was born in Boston, on the 27th of December, 1807, and died in Cambridge, on the 1st of December, 1899.

He was the son of Dr. John Dixwell, who graduated from Harvard College in 1796 and received the degree of M.D. in 1811, and of Esther Sargent, his wife. Dr. Dixwell was a descendant of the regicide.

Mr. Dixwell was educated at the Boston Latin School, and entered Harvard College when he was not yet sixteen years old. In college he was recognized as an admirable scholar, and the interest which he then showed in literature and music continued through his life, and afforded a solace to his declining years. Graduating from college in the class of 1827, he turned his attention to teaching, though perhaps not then realizing that this was to be the profession of his life. The two years during which he was sub-master of the Boston Latin School were followed by several years spent in the study of law in the office of one of the most eminent lawyers of Boston, Charles G. Loring. He was admitted to the bar in October, 1833, and for three years he practised

his profession; but in the autumn of 1836 he was chosen head-master of the Boston Latin School, and at once took up his work as an instructor of youth, a work which was to occupy his best thoughts and efforts for over a generation. In 1851, owing to certain municipal regulations, he felt called upon to resign his position, and at once opened "The Private Latin School" in Boylston Place, which from its start became very popular. Here he labored for twenty-one years, and when in 1872 he gave up the school with which his name had been so long associated, he found that he had taken part during the course of his teaching in preparing between four and five hundred graduates of Harvard for admission to college, besides teaching many others whose lives bear witness to his instruction.

After relinquishing the active duties of his school, Mr. Dixwell led a quiet and retired life in Cambridge, which he had chosen for his residence in 1842. Here he spent the remainder of his long life, except during two trips to Europe and his summer outings in the mountains or at the seashore. He found in Cambridge the congenial literary atmosphere which he enjoyed, and he contributed his share to the social and scientific life of Cambridge and of Boston. He was a member of various societies, and among others of the American Oriental Society, the Harvard Musical Association, and of our own Society, having been elected to the Academy in August, 1848. But in "The Scientific Club" of Cambridge he took more pleasure, perhaps, than in any other, for here he enjoyed the social intimacy of Agassiz, Peirce, Gray, Quincy, Sparks, Walker, Hill, Everett, Felton, Wyman, and of many others who have held distinguished rank in literary, professional, and scientific circles. With President Felton he had the still closer tie which came from their having been roommates in college.

Though Mr. Dixwell's life was a quiet one by choice, he did not neglect his duties as a citizen and church-goer. He early saw the necessity of manual training in the public schools, and served for many years as a trustee of the Parish fund of his church.

He thoroughly enjoyed his travels in Europe, as it gave him the opportunity which he had long wished for, of wandering through classic scenes and of seeing the wonders of classic and modern art, with which he had already become acquainted through his studies. He is said to have been more familiar with the topography of Rome than were many who had lived there for many years.

He was an admirable classical scholar, and his translations into Latin verse give evidence of his thorough knowledge of the language and of

his ready skill in its use. A little volume o
Senectutis," published in 1885, is a proof tl
the critical keenness of his mind. English v
his pen, and the lines which for many years
for the annual family gatherings, in which
interest and pleasure, will long be rememb
privilege of listening to them, for their te
their humor.

But it is as a teacher that Mr. Dixwell is
tant instructor in the public schools of Bosto
Boston Latin School, and as the master of
many years, his influence over the educati
wide. His coming to the Latin School w
accurate scholarship and a high moral tone
strict discipline in the management of that i
tations were justified in both the great sch
nected. One of his early scholars at the
him as a stimulating and encouraging te
accuracy, but trying to make his pupils see
whose work they were reading; as a strict d
dignified bearing, something of a martinet,
who were not able to see beneath the some
kindliness of his nature.

He was not only a good classical scholar bu
the branches which were taught in his school
been dull indeed who, needing an explanat
Mr. Dixwell's presence without having the di
away.

Ready to excuse errors of judgment or of
to condone moral faults, and his standard i
taught under his care was high. Bright sc
assisted in their work, and to dull scholars h
helping hand, but to wilful idleness he wa
anxious to deal justly with all, and if in any
do so, it was not owing to any want of g
towards the scholar.

With a very high standard of honor in hi
munion with his fellowmen, he was not alwa
ance for the errors of others, and this led him
narrow view of his duty; but all who have

with pleasure the dignified cordiality of his greeting, his kindly sympathy in others' joys and sorrows, his tenderness of heart, and his widespread interest in all that was going on about him. These traits continued to the last, even gaining in intensity as his long life approached its end.

CHARLES P. BOWDITCH.

JOHN CUMMINGS.

HON. JOHN CUMMINGS of Woburn, Mass., was elected Resident Fellow of the Academy, in Class III., Section 3, on the 12th of October, 1881. He was at the time well known in this section of the State as generously promoting the teaching of Natural Science in the public schools, and as liberally aiding institutions and individuals in the prosecution of more advanced scientific work. He was Vice-President of the Boston Society of Natural History, and had materially contributed to its museum by the gift of valuable collections, while the botanical specimens were being arranged and multiplied by his liberality.

One of his noteworthy contributions was the entire financial support he gave to the "Teachers' School of Science" for the first two years of its existence. When he was elected to the Academy this school had become of established value in the diffusion of scientific knowledge and in advancing the true method of teaching from objects and natural features.

At the same time he was identified with those who were establishing and building up the Massachusetts Institute of Technology. He was early made a member of its Corporation and was serving as its Treasurer, an office which he filled with great credit during a long period in the history of the institution when it most needed the services of a treasurer who believed in it and who had the energy and the courage to struggle with many difficulties and discouragements. To him the Institute of Technology is deeply indebted for its present condition.

He was filling many positions of confidence and responsibility and was highly esteemed in business circles. He was President of the Shawmut National Bank; he had served as President of the Boston Board of Trade and of the Shoe and Leather Association; and he had held important offices in the Massachusetts Charitable Mechanic Association, Massachusetts Horticultural Society, and the Perkins Institution for the Blind: he was State Director of the Boston and Albany Railroad, also a director of the Eastern Railroad. He had rendered valuable service as a mem-

ber of the Board of Finance of the Centennial Exposition at Philadelphia, and he had most liberally served his native town of Woburn in performing the duties of many offices and in the support of its public schools.

Such are some of the facts in the life and activities of Mr. Cummings which made him worthy of fellowship in the American Academy of Arts and Sciences.

Besides contributing to the support of institutions and working zealously to make the teachings of science more widely known, he manifested a very unusual interest in the study of nature. He made himself very familiar with the various species of plants growing in the region of his large farm in Woburn, and he profited by every opportunity to become acquainted with the minerals, the rocks, and the physical features of the vicinity. He was a good example of that notable class of men who in the earlier days of science devoted as many hours to the study of nature as their secular duties would permit. In all the various fields of work with which he became associated he was appreciated for the readiness and correctness of his judgment, for the energy with which he labored in the causes he espoused, for his invariable adherence to the highest standard of integrity and of right doing, and for his strong individuality of character.

Wm. H. Niles.

JOHN CODMAN ROPES.

John Codman Ropes was born in St. Petersburg, Russia, April 28, 1836, and died at his house, 99 Mt. Vernon Street, Boston, early in the morning of October 28, 1899. He was elected a Fellow of the Academy in May, 1885. His father was William Ropes, a native of Salem, and his mother was Mary Anne Codman, daughter of Hon. John Codman. William Ropes was for some time engaged in business in St. Petersburg, but removed to London in 1837 and lived for some time at Islington, where a younger son, the late Dr. F. C. Ropes, was born.

After the return of the family to Boston John Ropes studied for a while at the Chauncy Hall School, but at about the age of fourteen he was obliged to leave school on account of a physical infirmity. Up to that time he had been perfectly well and his figure was erect and shapely. But at about that time a slight curvature of the spine became apparent, which increased rapidly until it became a noticeable malformation. This physical deformity did not embarrass the action of heart or lungs, and during his entire life his health was remarkably good. But nevertheless

the deformity was a very serious burden and prevented Ropes from engaging in activities which would have been most congenial to him. I might add that to those who loved him — and no one knew him who did not — this malformation was simply non-existent. In sitting and talking with him one never thought of him as different from other men.

After leaving the Chauncy Hall School, Ropes was for a while under the care of Dr. Buckminster Brown. He then resumed his studies under Professor Goodwin, who acted as his private tutor and fitted him for college. He was graduated at Harvard in 1857 and soon afterwards entered the Law School, where he received his LL.B. in 1861. While he was proficient in the work of the Law School, it is interesting to observe that in that early time he also took a deep interest in questions of philosophy and religion. He was always a man of profoundly religious nature, with all the strength and earnestness of Puritanism, but without its ascetic features. In the year of his graduating at the Law School he received the Bowdoin prize for an essay on "The Limits of Religious Thought," — a title which strongly suggests that his mind had been exercised by the famous book of Dean Mansel which we were all then reading. For a short time Ropes studied in the office of Peleg W. Chandler and George O. Shattuck. He was admitted to the bar November 28, 1861, and continued to practise law in Boston until the time of his death. In 1865 he formed a partnership with John Chipman Gray of the class of 1859; and thirteen years later W. C. Loring of the class of 1872 was added to the firm, which has since been known as Ropes, Gray and Loring. Ropes' professional work was almost entirely confined to the office. Possibly his physical difficulty may have had something to do with this. He had all the qualities which might have placed him in the very highest ranks as an advocate before the court. He had an almost infallible scent for the essential points in a case, he could disentangle the most complicated details, he could hunt for evidence with a kind of cosmic patience that took everything with the utmost deliberation but never let slip the minutest detail, and he could marshal his arguments with a logical power that was equalled only by the artistic beauty of statement. To hear him argue any point was a genuine delight both to one's reason and to one's æsthetic sense. With all these rare endowments as an advocate, Ropes confined himself principally to business that could be done in the office, especially to the care and management of trust estates. At the time of his death there were more than a hundred trust estates, large and small, in his hands. He had long ago established his reputation as a safe person for taking care of money. He

always showed sound judgment in making
that one secret of his success was that minute
detail which characterized everything that he

The high qualities which might have made
a rich field for their employment in work d
and it is after all by that literary work that h
widely known. The recollection of his prof
pass away or be confined to very few person
tion. But his contributions to history have
to secure for them a very long life. His pub
entirely to military history, in which his two
of Napoleon and the Civil War in Ameri
Ropes' nature an infusion of the true soldie
competent for service, he would probably ha
War, like his younger brother Henry, wh
Gettysburg. I fancy that the incapacity for
John Ropes, but it never seemed to disturb h
could not be useful in one way he could in
follow in the footsteps of Alexander, he migh
The thought of writing a history of the Civi
with him into a settled purpose, and very adn
aration which he made for it. It was natu
most in his mind should come up for discussi
hours at the club. Gradually there grew up
at his house, meetings in which veterans of w
their experiences and discuss mooted questio
aged the preservation of every scrap of exper
record, and thus grew up the habit of prep
read and discussed at these informal mee
became the founder of a most valuable inst
torical Society of Massachusetts. For seve
meetings at Ropes' house, where the speaker
dine before the meeting and where the sessio
social glass and abounding good-fellowship.
Society, though few in number, are of grea
has found a permanent habitation in one
Armory where Ropes, some time ago, placed
able historical library.

One of the first literary results of these stu
ination of the Virginia Campaign of General

of which was furnished by Ropes in his volume entitled "The Army under Pope," being one of the volumes of Scribner's series on the Civil War. Among other things it may be said of this book that it completely exonerates General Fitz John Porter from the charges brought against him after the second battle of Bull Run and upon which he was so unjustly and cruelly condemned. I have been told that Ropes' weighty presentation of the case exerted no small influence upon the final verdict which declared General Porter innocent and went as far as possible toward repairing the grievous wrong that had been done. If no other result had come from founding the Military Historical Society, this alone would have more than justified its existence.

But Ropes' *magnum opus*, "The Story of the Civil War," was unfortunately never completed. It would have filled four volumes, and death removed the author soon after the publication of the second. The loss is one that can never be made good. Other writers of course may go over the period which Ropes failed to cover, but nobody can complete his book, for it is a case in which the writer's individual characteristics and personal experience are the all-important features. We have heard much in recent years of the advantages of the co-operative method in writing history, whereby a hundred experts may take each a small fragment of the ground to be covered. The merits of such a method are not denied, but it has one great defect: it gives us Hamlet with the Prince of Denmark left out. In an historical narrative nothing can make up for the personality of the narrator. A hundred experts on the Civil War would not fill Ropes' place for the simple reason that their hundred individual experiences cannot be combined in the same stream of consciousness. Ropes had gathered experience from every quarter; he had not only read pretty much everything worth reading on his subject, he had not only delved with endless patience in the original documents, but he had obtained through social intercourse with soldiers now passed away a truly enormous fund of information, a great part of which has surely perished with him. I remember that during the last two or three years the thought sometimes occurred to him that he might not live to finish his book. He told me one day that he only lacked eight years of being three score and ten, and that eight years were all too short a period for finishing the two volumes that remained to be done; he must therefore "scorn delight and live laborious days." He was always extremely fond of society; no man more keenly enjoyed a dinner-party or an evening at the club, and I can testify that sometimes after club hours were over we used to enjoy prolonging our friendly chat quite into the morning hours;

but in these latter days Ropes became much more chary of his time and subjected himself to a kind of discipline in order that his work might be finished.

In another direction and in dealing with a more limited theme, he achieved a finished piece of work. He had always entertained a warm admiration for the First Napoleon. It was natural that such an acute military critic should admire such transcendent military genius. But Ropes carried his admiration to an extent with which not all his friends found it easy to sympathize. In his little book entitled "The First Napoleon" Ropes appears as the great Corsican's advocate, and his case is presented with consummate skill. It has all the more weight because the author is far too skilful to weaken his case by over statement or by any too conspicuous warmth of enthusiasm. It is a masterly piece of writing, although in its philosophic grasp of the man and the period it is surely far inferior to the book published about the same time by the late Sir John Seeley.

It was in relation to the Waterloo Campaign that Ropes produced the completely finished work already alluded to. No battle of the nineteenth century has called for so much discussion as Waterloo; and most of the discussion has centred about the question, "Why did Napoleon lose the battle?" The books on this subject are legion, and they present us with an English view of the situation and a Prussian view, and ever so many French views, according to the political and personal predilections of the writers. Usually we find some particular antecedent selected as explaining the mighty result, while other antecedents receive inadequate attention or are passed over. One writer is impressed with the inefficiency of Grouchy, another one traces the catastrophe to the aimless wanderings of Erlon's corps on the sixteenth of June, and so on. But in Ropes' monograph what chiefly impresses us is the fact that he weighs every circumstance with the greatest care and puts real mental effort into the work of estimating the precise share which each circumstance took in the general mass of causation. In the first place the quality of the French army is duly considered and compared with the quality of the allied forces. Then such facts as the Emperor having Soult for Chief of Staff, an unaccustomed position for that able marshal, his feeling it necessary to leave at Paris the invincible Davoust, and other like circumstances, receive due attention. The mysterious movements of Erlon, which prevented his being of any use either to Ney at Quatre Bras or to Napoleon at Ligny, are more acutely analyzed than in any other book. Then the consequences of the very incomplete defeat of Blücher on the

sixteenth are carefully considered. Then Napoleon's great and unusual blunder in assuming an eastward retreat for the Prussians and acting upon the assumption without verifying it, is properly characterized. The share wrought by the muddy roads and the rains is not forgotten, nor the physical weaknesses which hampered the great general and allowed him now and then to be caught napping for a moment; the masterly position taken by Wellington; the effects of the topography; the extent to which the Emperor's attention was diverted early in the afternoon in the direction of Plancheuoit, — not one of these points is forgotten or slurred over. It is this minute quantitative consideration of details that impresses upon Ropes' historical writings their truly scientific character, and no theme could have been better calculated to exhibit it in its perfection than the campaign of Waterloo. One cannot read the book carefully without feeling that for once in the world something has been done so exhaustively that it will not need to be done again. It would seem almost impossible for the most fertile mind to offer a suggestion of anything actual, probable, or possible about Waterloo that our author has not already brought forward and considered. Those who write such books are few, and to study them is a great and profitable stimulus. As this monograph on Waterloo related to a subject already well understood in Europe, it immediately gave Ropes a high reputation in European circles, and I believe he is regarded by experts as one of the soundest military critics since the days of Jomini.

JOHN FISKE.

JOHN LOWELL

JOHN LOWELL, the fourth of that name in direct descent from the first minister of Newburyport, who died in 1767, was born in Boston on the 18th of October, 1824. He was elected, in October, 1877, a Fellow of this Academy, of which his great-grandfather had been one of the original incorporators in 1780, and both his father and grandfather Fellows.

At the time of his birth his father was living on the lower (southerly) corner of what are now Bedford and Chauncy streets; but at that time, between Bedford and Summer streets, at the points where Chauncy Street now turns off, there was on Summer Street a place called Chauncy Place, running about two-thirds of the way through, and then closed by a brick wall with two openings for foot passengers, but none for vehicles, and turning up from Bedford Street a similar place called Bedford Place, on the upper side of which and next to the wall stood the house of Judge Charles Jackson, having a large garden and pear

orchard extending down the place until it touched the garden of Judge Prescott, which stretched from there up Bedford Street towards Washington. The lower side of Bedford Place was occupied by a row of brick houses, and in the one at the corner, as has already been said, John Lowell was born.

In Chauncy Place, next to the dividing wall between that and Bedford Place, stood the Chauncy Hall School, then under the management of a well-known teacher, Gideon F. Thayer. To this school, partly perhaps from its nearness as well as for its reputation, Judge Lowell was sent, as soon as he was old enough to go to any man's school. He was fitted for college in the private school of Daniel G. Ingraham, who kept for more than twenty years the leading private classical school in Boston, and graduated at Harvard in 1843 at the age of eighteen years, with high distinction in Greek, Latin, Philosophy, and History, — indeed it would seem that he must have been recognized as especially proficient in Greek, as at the Sophomore Exhibition in October, 1841, he was one of the speakers in A Greek Dialogue, "Extract from Shakspeare's Henry the Fourth: Glendower and Hotspur;" and at the corresponding Exhibition in his Junior year, had a Greek oration, "Βύρων ἐν Ἑλλάδι." He was among the first scholars in his class: of his Commencement part, an English oration, the Rev. Dr. John Pierce wrote in his diary: "The subject of this oration was 'The Battle of the Nile,' — eight minutes in length, a summary of the principal facts." *

After leaving college Lowell entered the Dane Law School, and remained there for the full course of two years. He was then for a year in the office of Mr. Charles G. Loring, and was admitted to the bar in 1846. Directly afterwards he went to Europe with his father and family, and was absent about a year. On his return he formed a connection with his brother-in-law, Mr. William Sohier, and began the practice of the law. This connection lasted until 1857, when he took an office by himself.

The business in Mr. Sohier's office was mostly chamber practice, and largely connected with the management of trust estates, and Mr. Lowell's work there was not such as to give him the opportunity for any especial display of ability, or to attract any one's attention. His name, I think, appears only twice in the Massachusetts Reports for this period. In the autumn of 1857 he separated from Mr. Sohier almost at the moment when the financial difficulties of that time were reaching their

* Mass. Hist. Soc. Proceedings, Series II., V. p. 237.

crisis. These difficulties affected very seriously the manufacturing interests of this part of the Commonwealth, and many of the large mercantile firms who had been the agents of the factories. The family and business connections of Mr. Lowell and his father naturally caused him to be consulted in some of these matters, and he thus became interested in the consideration of questions arising in bankruptcy and insolvency, a branch of the law in which as a judge he subsequently acquired a well-deserved and widespread reputation.

He continued in the practice of the law until 1865. During part of this time he had charge of the "Law Reporter," a monthly journal then published in Boston. From May, 1856, he was for two years its sole editor, and afterwards until April, 1860, joint editor with Mr. Samuel M. Quincy of the Boston bar. Four volumes (Vols. 19, 20, 21, and 22) were published while he was editor.

Upon the resignation of Judge Sprague of the United States District Court of Massachusetts, in March, 1865, Mr. Lowell was appointed his successor. The appointment was wholly unsolicited by Mr. Lowell. It was made upon the recommendation of a few of the leaders of the Suffolk bar. The letter which they addressed to the President was written by Mr. Charles G. Loring, and was signed by himself, Mr. Charles B. Goodrich, Mr. Sidney Bartlett, Judge Josiah G. Abbott, Mr. Samuel E. Sewall, Mr. Edward D. Sohier, Mr. George Bemis, and Mr. Dwight Foster. It was carried to Washington at the same time with Judge Sprague's resignation by Mr. Richard H. Dana, Jr., who was then the United States attorney here. The nomination was suggested to Mr. Lincoln by Mr. Sumner and Mr. Dana, and was made and confirmed on the same day.

The appointment was one peculiarly gratifying to Mr. Lowell, for his great-grandfather, Judge John Lowell, had been appointed in 1789 by General Washington to this same office, and was the first District Judge of the United States for the District of Massachusetts, and Mr. Lowell felt a natural and proper pride and pleasure in succeeding to the honorable position and duties of his ancestor. In 1878, on the death of the Honorable George F. Shepley, Judge of the Circuit Court of the United States for the First Circuit, he was made Circuit Judge, thus again succeeding his great-grandfather, who had been appointed by President John Adams to a similar position in the court which the Federalists created in the last year of President Adams's administration, only to have the act creating it repealed and the court destroyed by the Democrats under Jefferson, as the simplest mode of getting rid of the Federalist judges whom Adams had appointed.

In May, 1884, a little more than nineteen years after his first appointment to the bench, Judge Lowell resigned his position as Circuit Judge, and resumed the practice of the law in Boston. His long period of judicial service had given the public ample opportunity to recognize his legal ability and wisdom, and from the time he returned to the bar until his last short illness, he was fully occupied with professional work. He served as arbitrator, or sat as a commissioner or special master in many causes and matters of importance; he was retained as counsel in litigations involving large interests and difficult questions, and his advice was constantly sought in solving the perplexities that arise in the administration of the law of bankruptcy. Fortunately for him this professional work was interesting and stimulating and sufficiently engrossing to distract his mind from domestic griefs and anxieties, which weighed upon him heavily at intervals.

During these years he two or three times visited Europe in the summer with his family, before a severe accident to his wife rendered it difficult for her to travel.

He married, in 1853, Lucy Buckminster, the only daughter of Mr. George B. Emerson and of Olivia Buckminster, his wife, daughter of the Rev. Joseph Buckminster of Portsmouth, N. H., and sister of the Rev. Joseph Stevens Buckminster of Brattle Square Church, Boston. For some time after his marriage Judge Lowell lived at No. 11 Chestnut Street, in the house in which his wife was born, but in 1858 he purchased a farm lying between Chestnut Hill and Hammond's Pond, where he lived until his death on the 14th of May, 1897. He had inherited a taste for country life and an interest in trees and plants, shrubs and flowers, from which he derived during these years great enjoyment; and the time which he passed in going about his place, in looking at the improvements he had made, and considering those which he proposed to make, undoubtedly contributed to the preservation of his health and the prolongation of his life. He was not a man of remarkable physique, yet until his last illness it is doubtful whether he was ever detained from his office for two days at a time by any physical ailment.

In addition to the labors of his profession, he filled during these latter years many positions of importance and responsibility. In 1896 he was appointed by Governor Wolcott chairman of the commission to revise the laws of Massachusetts on the subject of taxation, and held this office at the time of his death. He was also Vice-President of the Massachusetts General Hospital, of which he had been for many years one of the Trustees; was President of the Trustees of the Peabody Fund, an Overseer

of Harvard University, and a Member of the Massachusetts Historical Society. He received the degree of Doctor of Laws from Williams College in 1870, and from Harvard in 1871.

Before his appointment as District Judge, Mr. Lowell's work at the bar had been chiefly office practice. His clients, if not very numerous, were warmly attached to him, were continually demanding his counsel, and had the most implicit confidence in the opinions he gave them. When consulted by any one of them he rarely looked at a book; but after hearing what the client had to say, would sit perfectly quiet, until he had sufficiently considered the question, and then advise him in a way showing intuitive sagacity and familiarity both with the fundamental principles of the law and their application by the courts. He was always a diligent student, reading carefully, digesting slowly, and assimilating thoroughly what was new or seemed to him important in the volumes of reports that from time to time appeared, so that when his judicial work began he was well equipped for the duties that devolved upon him.

The District Court of the United States, of which he was at first appointed Judge, is a court of limited and peculiar jurisdiction; it has the exclusive cognizance of admiralty and maritime cases, and of all crimes committed upon the high seas; it is also a prize court, and sits as a criminal court, for the trial of offences against the laws of the United States, such as violations of the post-office laws, revenue laws, etc. The number of jury trials in this court is, however, very limited and mostly confined to criminal cases, usually of great simplicity. Judge Lowell's want of experience in practice before a jury, and in dealing with juries, was for this reason a source of much less embarrassment to him in this court than it would have been in most others. He had, in fact, before his appointment tried only one jury case, and was perfectly aware of the difficulties under which he labored in public speaking. Time and constant practice diminished these difficulties, and made it more easy for him to preside at jury trials, as he gradually overcame the obstacles which sprang largely from his want of training and experience, and a lack of confidence in himself. The civil war was not over when he was appointed to the bench, and the effect of the destruction of our merchant marine by the guns of the Confederate cruisers, and of the transfer of our ships to foreign owners, now so evident in many other ways besides that of the sadly diminished number and importance of the suits in Admiralty, had not then made themselves thoroughly felt. At the time of his appointment there were many causes pending which Judge Sprague's long illness had prevented his hearing, and Judge Lowell had at first no lack of

Admiralty suits of all kinds, including some difficult questions in prize causes. The principles and practice of the Admiralty Courts were especially congenial to him. He was in full sympathy with the tenderness which that court has always shown for the ignorant and improvident sailor; and the cardinal rule of the Admiralty that no error of statement, or technical defect, or mistake in the kind of relief asked for, should interfere with or prevent such a decision of a cause as would work substantial justice between the parties, was in entire harmony with his view as to what should be the aim of all courts and judges so far as the established rules of law and the decided cases would permit, — an opinion which he held so strongly, that for his efforts to attain this end, he was at times called "wayward" in his decisions.

At the time of Judge Lowell's appointment, there was no national bankrupt act in force, although there was an insolvent act in Massachusetts with which and its operation he was very familiar; two years after he became the judge of the District Court, Congress passed the National Bankrupt Act of 1867, in the administration of which he won a distinction which placed him among the foremost, — it is perhaps not too much to say, at the head of the judges in this country, having original jurisdiction of cases in Bankruptcy and charged with the administration of this law.

As has already been said, the subject of Bankruptcy had interested him many years before his appointment to the bench; he had begun the preparation of the treatise on this branch of the law which since his death has been published by his son, and the work he had done on this book had made him unusually familiar with the underlying principles of the Bankrupt Laws and the adjudicated cases. The purposes of a bankrupt act, — to secure the equitable distribution of an insolvent debtor's assets among his creditors, to grant him his discharge from his antecedent liabilities if he has honestly surrendered his property to be distributed for the payment of his debts, — and, on the other hand, to prevent such a debtor, who has fraudulently concealed for his own advantage a part of his estate, or unfairly preferred some of his creditors, from receiving the benefit of the act, — these purposes equitable in both aspects, and the simplicity and directness of the methods of procedure under the practice in Bankruptcy, were all in harmony with his convictions of the useful and beneficent purposes of the law and the courts of justice, and made the administration of this law a congenial task, which he discharged not merely to the satisfaction of the bar, but to the approval of the mercantile class of the community whose interests are most affected by this law, who

are perfectly able to understand it and to judge whether it is wisely administered, and in the spirit of justice and fair dealing upon which it is founded. Upon Judge Lowell's retirement from the bench in May, 1884, the merchants of Boston invited him to a public dinner, that they might have an opportunity of testifying their high esteem and affectionate consideration for him as an administrator of the laws which most nearly concerned them in their business relations, whose decisions and interpretations of these laws had received the approval of the mercantile community throughout the land. This unusual tribute, coming from the source from which it emanated, was most gratifying to Judge Lowell as a proof that his administration of the Bankrupt Law had not only been in accord with the strong common sense of the business men of the community, but also with the principles of justice and equity which it has been the aim of every well-intended law of Bankruptcy to carry out. The mercantile community still further showed its appreciation of him by requesting him at a later date to prepare a new Bankrupt Act to be laid before Congress. But this act was unfortunately not passed.

The jurisdiction of the Circuit Court of the United States for the First Circuit, of which Judge Lowell was appointed Judge in 1878, includes the States of Maine, New Hampshire, and Rhode Island, as well as Massachusetts, and his duties as Circuit Judge brought him in contact with the members of the bar and the people of all these States; that he discharged these duties to their satisfaction was shown by the attendance of lawyers from every State in the circuit, at the bar meeting in Boston after his death, and by the abundant testimony they gave of their recognition and thorough appreciation of his worth and ability, both as a magistrate and a man. The business of the Circuit Court and the class of cases tried there is quite different from that of a District Court. It has no original jurisdiction in Bankruptcy or Admiralty, but in these matters sits only as a Court of Appeals. It deals more largely with cases at common law and with civil suits for violation of the revenue law. It has also jurisdiction of patent causes, a branch of the law which is thought to require some special aptitude for and knowledge of mechanics as well as of the physical sciences. Neither Judge Lowell's professional work at the bar nor on the bench had ever brought him to the study of this branch of the law, and he was at the outset and continued to be unduly distrustful of his ability to master and properly decide the patent cases that were brought before him. As he occasionally jocosely expressed it, "he was afraid of only one thing in the law, — those infernal machines." But he applied himself with the conscientiousness and thoroughness that

distinguished all his work to the study and investigation of these cases, and by the common consent of the counsel practising in patent cases, proved himself an excellent patent judge.

His judicial opinions are marked by clearness of thought, and the direct, terse, and vigorous expression of it, with no digressions, no discussions or dicta not absolutely necessary to the determination of the precise points before him. In deciding a cause he took the line of least resistance; if it were a short cut he availed himself of it, and this not so much because this course saved him labor, as because he intended his judgment to be confined to the determination of the case actually before him. He was careful, therefore, not to stray from the real questions at issue, and to avoid being beguiled into by-paths of interesting legal investigation which had but little or no tendency to enlighten or aid him in arriving at his conclusions, and were not important in determining his final results.

He had a natural aptitude for the law, one might almost say a legal instinct, and this was strengthened and quickened by thought and study; he possessed as a judge a remarkable intuition "for perceiving on which side lay the justice of any case and an equally remarkable ingenuity in showing that a decision in favor of that side was in accordance with the settled rules of law." When he found himself obliged to yield to precedents which prevented what justice seemed to him to require, he did so with a reluctance which he never tried to conceal and sometimes openly expressed. His quiet humor not infrequently enlivened the trial of a cause, and occasionally appeared in his Opinions, as when in denying a motion to set aside a verdict because one juror had been asleep during part of the trial, he said: "If one of the jurors was asleep, the defendant should have called attention to the fact at the time. There is no suggestion that it is newly discovered, and I cannot now say that the defendant may not have thought his interests were promoted by the actual course of the trial in this respect." Or, to quote one more instance, — in a suit where a ship owner contended that the master had forfeited his wages by taking on board some casks of Madeira wine, the ship articles prohibiting him from carrying *distilled spirits* under penalty of forfeiting his pay, Judge Lowell demolished the elaborate argument of the counsel for the ship owner by saying, "Wine is not distilled spirits, and cannot be made so by a usage of the port of New Bedford or any other process that I am acquainted with, except distillation."

Any attempt to characterize Judge Lowell's judicial qualities would be imperfect if it failed to recognize and call attention to the fact that

he had not merely the respect, but the warm affection of the members of the bar. His simple and unassuming manner claimed nothing, yet no one ever thought of treating him with discourtesy. His natural kindness led him to treat the youngest members of the bar and to listen to their arguments, however crudely presented, with a never-failing patience and consideration; and both on and off the bench, he was always, in his relations with them, cordial, friendly, and ready to give them the benefit of his wisdom and learning in any difficulty in which they might ask his advice, doing this in such a manner that he rather seemed to be receiving than conferring a favor. He was not merely a learned lawyer; he was also a lover of books, a great reader, catholic in his tastes, and spending in his library many of his hours of rest and recreation. In private life he was an agreeable companion, a loyal friend, a most devoted husband and father. He was not a demonstrative person, but "a quiet, self-contained, thoughtful, courageous, affectionate man, who kept his eye single for the right and the true, who did every duty with keen thoroughness, and who found his greatest pleasure in the companionship of those nearest and dearest to him."

THORNTON K. LOTHROP.

Other notices are postponed.

The number of new members elected during the year is as follows: Resident Fellows, 4; Associate Fellows, 5; Foreign Honorary Members, 4.

The roll of the Academy at present includes 194 Resident Fellows, 89 Associate Fellows, and 66 Foreign Honorary Members.*

* By transfer of an Associate Fellow to Resident Fellowship, and by election of new members at the annual meeting, the roll stands at date of publication 198 Resident Fellows, 93 Associate Fellows, and 69 Foreign Honorary Members.

American Academy of Arts and Sciences.

OFFICERS AND COMMITTEES FOR 1899-1900.

PRESIDENT.

ALEXANDER AGASSIZ.

VICE-PRESIDENTS.

Class I.	Class II.	Class III.
JOHN TROWBRIDGE.	ALPHEUS HYATT.	AUGUSTUS LOWELL.

CORRESPONDING SECRETARY.

SAMUEL H. SCUDDER, *May*, 1899—*January*, 1900.

WILLIAM M. DAVIS, *January*—*May*, 1900.

RECORDING SECRETARY.

WILLIAM WATSON.

TREASURER.

FRANCIS BLAKE.

LIBRARIAN.

A. LAWRENCE ROTCH.

COUNCILLORS.

Class I.	Class II.	Class III.
HENRY TABER,	BENJAMIN L. ROBINSON,	BARRETT WENDELL,
THEODORE W. RICHARDS,	WILLIAM T. COUNCILMAN,	EDWARD ROBINSON,
HARRY M. GOODWIN.	JOHN E. WOLFF.	JAMES B. AMES.

COMMITTEE OF FINANCE.

ALEXANDER AGASSIZ, FRANCIS BLAKE, AUGUSTUS LOWELL.

RUMFORD COMMITTEE.

ERASMUS D. LEAVITT, AMOS E. DOLBEAR, EDWARD C. PICKERING, ARTHUR G. WEBSTER, THOMAS C. MENDENHALL, CHARLES R. CROSS, THEODORE W. RICHARDS,

C. M. WARREN COMMITTEE.

FRANCIS H. STORER, HENRY B. HILL, CHARLES L. JACKSON, LEONARD P. KINNICUTT, ROBERT H. RICHARDS, SAMUEL CABOT, ARTHUR M. COMEY,

COMMITTEE OF PUBLICATION.

SAMUEL H. SCUDDER, SETH C. CHANDLER, CRAWFORD H. TOY.

COMMITTEE ON THE LIBRARY.

A. LAWRENCE ROTCH, HENRY W. HAYNES, SAMUEL HENSHAW.

AUDITING COMMITTEE.

HENRY G. DENNY, WILLIAM L. RICHARDSON.

LIST

OF THE

FELLOWS AND FOREIGN HONORARY MEMBERS.

(Corrected to May 20, 1900.)

RESIDENT FELLOWS.—198.

(Number limited to two hundred.)

Class I.—*Mathematical and Physical Sciences.*—79.

Section I.—20.

Mathematics and Astronomy.

Solon I. Bailey,	Cambridge.
Maxime Bôcher,	Cambridge.
William E. Byerly,	Cambridge.
Seth C. Chandler,	Cambridge.
J. Rayner Edmands,	Cambridge.
Gustavus Hay,	Boston.
Henry Mitchell,	Nantucket.
William F. Osgood,	Cambridge.
James Mills Peirce,	Cambridge.
Edward C. Pickering,	Cambridge.
William H. Pickering,	Cambridge.
John Ritchie, Jr.,	Boston.
John D. Runkle,	Cambridge.
T. H. Safford,	Williamstown.
Edwin F. Sawyer,	Brighton.
Arthur Searle,	Cambridge.
William E. Story,	Worcester.
Henry Taber,	Worcester.
O. C. Wendell,	Cambridge.
P. S. Yendell,	Dorchester.

Section II.—21.

Physics.

A. Graham Bell,	Washington, D.C.
Clarence J. Blake,	Boston.
Francis Blake,	Weston.
Charles R. Cross,	Brookline.
Amos E. Dolbear,	Somerville.
H. M. Goodwin,	Boston.
Edwin H. Hall,	Cambridge.
Hammond V. Hayes,	Cambridge.
William L. Hooper,	Somerville.
William W. Jacques,	Newton.
Frank A. Laws,	Boston.
Henry Lefavour,	Williamstown.
T. C. Mendenhall,	Worcester.
Benjamin O. Peirce,	Cambridge.
A. Lawrence Rotch,	Boston.
Wallace C. Sabine,	Cambridge.
John S. Stone,	Boston.
Elihu Thomson,	Swampscott.
John Trowbridge,	Cambridge.
A. G. Webster,	Worcester.
Robert W. Willson,	Cambridge.

Section III.—24.

Chemistry.

Samuel Cabot,	Boston.
Arthur M. Comey,	Cambridge.
James M. Crafts,	Boston.
Thos. M. Drown,	So. Bethlehem, Pa.
Charles W. Eliot,	Cambridge.
Thomas Gaffield,	Boston.
Henry B. Hill,	Cambridge.

Charles L. Jackson,	Cambridge.
Walter L. Jennings,	Worcester.
Leonard P. Kinnicutt,	Worcester.
Charles F. Mabery,	Cleveland, O.
Arthur Michael,	Boston.
George D. Moore,	Worcester.
Charles E. Munroe,	Wash'gton, D.C.
John U. Nef,	Chicago, Ill.
Arthur A. Noyes,	Boston.
Robert H. Richards,	Boston.
Theodore W. Richards,	Cambridge.
Charles R. Sanger,	Cambridge.
Stephen P. Sharples,	Cambridge.
Francis H. Storer,	Boston.
Henry P. Talbot,	Newton.
Charles H. Wing,	Ledger, N. C.
Edward S. Wood,	Boston.

SECTION IV. — 14.

Technology and Engineering.

Eliot C. Clarke,	Boston.
Ira N. Hollis,	Cambridge.
Gaetano Lanza,	Boston.
E. D. Leavitt,	Cambridgeport.
William R. Livermore,	Boston.
Hiram F. Mills,	Lowell.
Cecil H. Peabody,	Boston.
Alfred P. Rockwell,	Manchester.
Andrew H. Russell,	Wash'ton, D.C.
Peter Schwamb,	Arlington.
Charles S. Storrow,	Boston.
George F. Swain,	Boston.
William Watson,	Boston.
Morrill Wyman,	Cambridge.

CLASS II. — *Natural and Physiological Sciences.* — 64.

SECTION I. — 13.

Geology, Mineralogy, and Physics of the Globe.

H. H. Clayton,	Milton.
Algernon Coolidge,	Boston.
William O. Crosby,	Boston.
William M. Davis,	Cambridge.
Benj. K. Emerson,	Amherst.
O. W. Huntington,	Newport, R. I.
Robert T. Jackson,	Boston.
William H. Niles,	Cambridge.
John E. Pillsbury,	Boston.
Nathaniel S. Shaler,	Cambridge.
Robert DeC. Ward,	Cambridge.
John E. Wolff,	Cambridge.
J. B. Woodworth,	Cambridge.

SECTION II. — 11.

Botany.

Geo. E. Davenport,	Medford.
William G. Farlow,	Cambridge.
Charles E. Faxon,	Boston.
Merritt L. Fernald,	Cambridge.
George L. Goodale,	Cambridge.
H. H. Hunnewell,	Wellesley.
John G. Jack,	Boston.
B. L. Robinson,	Cambridge.
Charles S. Sargent,	Brookline.
Arthur B. Seymour,	Cambridge.
Roland Thaxter,	Cambridge.

SECTION III. — 25.

Zoölogy and Physiology.

Alexander Agassiz,	Cambridge.
Robert Amory,	Boston.
James M. Barnard,	Milton.
Henry P. Bowditch,	Boston.
William Brewster,	Cambridge.
Louis Cabot,	Brookline.
William E. Castle,	Cambridge.
Samuel F. Clarke,	Williamstown.
W. T. Councilman,	Boston.
Charles B. Davenport,	Chicago, Ill.
Harold C. Ernst,	Boston.
J. Walter Fewkes,	Washington, D.C.
Edward G. Gardiner,	Boston.
Samuel Henshaw,	Cambridge.
Alpheus Hyatt,	Cambridge.

John S. Kingsley, Somerville.
Edward L. Mark, Cambridge.
Charles S. Minot, Boston.
Edward S. Morse, Salem.
George H. Parker, Cambridge.
James J. Putnam, Boston.
Samuel H. Scudder, Cambridge.
William T. Sedgwick, Boston.
James C. White, Boston.
William M. Woodworth, Cambridge.

SECTION IV. — 15.

Medicine and Surgery.

Samuel L. Abbot, Boston.
Edward H. Bradford, Boston.
Arthur T. Cabot, Boston.
David W. Cheever, Boston.
Frank W. Draper, Boston.
Thomas Dwight, Boston.
Reginald H. Fitz, Boston.
Charles F. Folsom, Boston.
Frederick I. Knight, Boston.
Samuel J. Mixter, Boston.
W. L. Richardson, Boston.
Theobald Smith, Boston.
O. F. Wadsworth, Boston.
Henry P. Walcott, Cambridge.
John C. Warren, Boston.

CLASS III. — *Moral and Political Sciences.* — 55.

SECTION I. — 11.

Philosophy and Jurisprudence.

James B. Ames, Cambridge.
Charles C. Everett, Cambridge.
Horace Gray, Boston.
John C. Gray, Boston.
G. Stanley Hall, Worcester.
Nathaniel Holmes, Cambridge.
John E. Hudson, Boston.
Francis C. Lowell, Boston.
Josiah Royce, Cambridge.
Jeremiah Smith, Cambridge.
James B. Thayer, Cambridge.

SECTION II. — 20.

Philology and Archæology.

William S. Appleton, Boston.
Charles P. Bowditch, Boston.
Lucien Carr, Cambridge.
Franklin Carter, Williamstown.
Joseph T. Clarke, Boston.
Henry G. Denny, Boston.
William Everett, Quincy.
William W. Goodwin, Cambridge.
Henry W. Haynes, Boston.
Charles R. Lanman, Cambridge.
David G. Lyon, Cambridge.
Bennett H. Nash, Boston.
Frederick W. Putnam, Cambridge.
Edward Robinson, Boston.
F. B. Stephenson, Boston.
Joseph H. Thayer, Cambridge.
Crawford H. Toy, Cambridge.
John W. White, Cambridge.
John H. Wright, Cambridge.
Edward J. Young, Waltham.

SECTION III. — 11.

Political Economy and History.

Charles F. Adams, Lincoln.
Edward Atkinson, Boston.
Andrew M. Davis, Cambridge.
John Fiske, Cambridge.
A. C. Goodell, Salem.
Henry C. Lodge, Nahant.
A. Lawrence Lowell, Boston.
Augustus Lowell, Boston.
James F. Rhodes, Boston.
Denman W. Ross, Cambridge.
Charles C. Smith, Boston.

SECTION IV. — 13.

Literature and the Fine Arts.

Francis Bartlett,	Boston.
John Bartlett,	Cambridge.
Arlo Bates,	Boston.
George S. Boutwell,	Groton.
J. Elliot Cabot,	Brookline.
T. W. Higginson,	Cambridge.
George L. Kittredge,	Cambridge.
S. R. Koehler,	Boston.
Charles G. Loring,	Boston.
Percival Lowell,	Boston.
Charles Eliot Norton,	Cambridge.
Horace E. Scudder,	Cambridge.
Barrett Wendell,	Boston.

ASSOCIATE FELLOWS.—93.

(Number limited to one hundred. Elected as vacancies occur.)

Class I.—*Mathematical and Physical Sciences.*—34.

Section I.—14.

Mathematics and Astronomy.

Edward E. Barnard, Williams Bay, [Wis.
S. W. Burnham, Chicago.
George Davidson, San Francisco.
Fabian Franklin, Baltimore.
Asaph Hall, Cambridge, Mass.
George W. Hill, W. Nyack, N.Y.
E. S. Holden, Washington.
James E. Keeler, Mt. Hamilton, Cal.
Emory McClintock, Morristown, N.J.
Simon Newcomb, Washington.
Charles L. Poor, Baltimore.
George M. Searle, Washington.
J. N. Stockwell, Cleveland, O.
Chas. A. Young, Princeton, N. J.

Section II.—6.

Physics.

Carl Barus, Providence, R.I.
J. Willard Gibbs, New Haven.
S. P. Langley, Washington.
A. A. Michelson, Chicago.
Ogden N. Rood, New York.
H. A. Rowland, Baltimore.

Section III.—7.

Chemistry.

Wolcott Gibbs, Newport, R.I.
Frank A. Gooch, New Haven.
S. W. Johnson, New Haven.
J. W. Mallet, Charlottesville, Va.
E. W. Morley, Cleveland, O.
J. M. Ordway, New Orleans.
Ira Remsen, Baltimore.

Section IV.—7.

Technology and Engineering.

Henry L. Abbot, New York.
Cyrus B. Comstock, New York.
W. P. Craighill, Charlestown, W. [Va.
F. R. Hutton, New York.
George S. Morison, Chicago.
William Sellers, Edgemoor, Del.
Robt. S. Woodward, New York.

Class II.—*Natural and Physiological Sciences.*—30.

Section I.—14.

Geology, Mineralogy, and Physics of the Globe.

Cleveland Abbe, Washington.
George J. Brush, New Haven.
Edward S. Dana, New Haven.
Walter G. Davis, Cordova, Arg.
George M. Dawson, Ottawa.
G. K. Gilbert, Washington.
Clarence King, New York.
Joseph LeConte, Berkeley, Cal.
J. Peter Lesley, Milton, Mass.
S. L. Penfield, New Haven.
J. W. Powell, Washington.
R. Pumpelly, Newport, R.I.
A. R. C. Selwyn, Ottawa.
Charles D. Walcott, Washington.

SECTION II. — 5.

Botany.

L. H. Bailey,	Ithaca.
D. H. Campbell,	Palo Alto, Cal.
J. M. Coulter,	Chicago.
John D. Smith,	Baltimore.
W. Trelease,	St. Louis.

SECTION III. — 5.

Zoölogy and Physiology.

Joel A. Allen,	New York.
W. K. Brooks,	Lake Roland, Md.
S. Weir Mitchell,	Philadelphia.
A. S. Packard,	Providence, R.I.
A. E. Verrill,	New Haven.

SECTION IV. — 6.

Medicine and Surgery.

John S. Billings,	New York.
Jacob M. Da Costa,	Philadelphia.
William Osler,	Baltimore.
Alfred Stillé,	Philadelphia.
Wm. H. Welch,	Baltimore.
H. C. Wood,	Philadelphia.

CLASS III. — *Moral and Political Sciences.* — 29.

SECTION I. — 7.

Philosophy and Jurisprudence.

James C. Carter,	New York.
Joseph H. Choate,	New York.
Melville W. Fuller,	Washington.
William W. Howe,	New Orleans.
William Mitchell,	St. Paul.
Charles S. Peirce,	Milford, Pa.
T. R. Pynchon,	Hartford, Conn.

SECTION II. — 8.

Philology and Archæology.

Timothy Dwight,	New Haven.
B. L. Gildersleeve,	Baltimore.
D. C. Gilman,	Baltimore.
T. R. Lounsbury,	New Haven.
Rufus B. Richardson,	Athens.
E. E. Salisbury,	New Haven.
Thomas D. Seymour,	New Haven.
A. D. White,	Ithaca, N.Y.

SECTION III. — 6.

Political Economy and History.

Henry Adams,	Washington.
G. P. Fisher,	New Haven.
H. E. von Holst,	Chicago.
Henry C. Lea,	Philadelphia.
Henry M. Stevens,	Ithaca.
W. G. Sumner,	New Haven.

SECTION IV. — 8.

Literature and the Fine Arts.

James B. Angell,	Ann Arbor, Mich.
L. P. di Cesnola,	New York.
H. H. Furness,	Wallingford, Pa.
R. S. Greenough,	Florence.
Augustus St. Gaudens,	New York.
John S. Sargent,	London.
E. C. Stedman,	Bronxville, N.Y.
W. R. Ware,	New York.

FOREIGN HONORARY MEMBERS.—69.

(Number limited to seventy-five. Elected as vacancies occur.)

Class I.—*Mathematical and Physical Sciences.*—23.

Section I.—7.

Mathematics and Astronomy.

Arthur Auwers,	Berlin.
George H. Darwin,	Cambridge.
H. A. E. A. Faye,	Paris.
Charles Hermite,	Paris.
Sir William Huggins,	London.
Otto Struve,	Karlsruhe.
H. C. Vogel,	Potsdam.

Section II.—6.

Physics.

Ludwig Boltzmann,	Vienna.
A. Cornu,	Paris.
Oliver Heaviside,	Newton Abbot.
F. Kohlrausch,	Berlin,
Lord Rayleigh,	Witham.
Sir G. G. Stokes, Bart.,	Cambridge.

Section III.—6.

Chemistry.

Adolf Baeyer,	Munich.
Marcellin Berthelot,	Paris.
J. H. van't Hoff,	Berlin.
D. Mendeleeff,	St. Petersburg.
Sir H. E. Roscoe,	London.
Julius Thomsen,	Copenhagen.

Section IV.—4.

Technology and Engineering.

Sir Benjamin Baker,	London.
Lord Kelvin,	Largs.
Maurice Lévy,	Paris.
William C. Unwin,	London.

Class II.—*Natural and Physiological Sciences.*—23.

Section I.—6.

Geology, Mineralogy, and Physics of the Globe.

Sir Archibald Geikie,	London.
Albert Heim,	Zurich.
Sir John Murray,	Edinburgh.
A. E. Nordenskiöld,	Stockholm.
Henry C. Sorby,	Sheffield.
Heinrich Wild,	Zurich.

Section II.—6.

Botany.

J. G. Agardh,	Lund.
E. Bornet,	Paris.
Sir Joseph D. Hooker,	Sunningdale.
W. Pfeffer,	Leipsic.
H. Graf zu Solms-Laubach,	Strassburg.
Eduard Strasburger,	Bonn.

Section III. — 7.

Zoölogy and Physiology.

Sir Michael Foster,	Cambridge.
Carl Gegenbauer,	Heidelberg.
Ludimar Hermann,	Königsberg.
A. von Kölliker,	Würzburg.
A. Kovalevsky,	St. Petersburg.
H. de Lacaze-Duthiers,	Paris.
Elias Metschnikoff,	Paris.

Section IV. — 4.

Medicine and Surgery.

W. Kühne,	Heidelberg.
Lord Lister,	London.
F. v. Recklinghausen,	Strassburg.
Rudolph Virchow,	Berlin.

Class III. — *Moral and Political Sciences.* — 23.

Section I. — 5.

Philosophy and Jurisprudence.

Heinrich Brunner,	Berlin.
F. W. Maitland,	Cambridge.
Sir Frederick Pollock, Bart.,	London.
Baron Russell of Killowen,	Tadworth.
Henry Sidgwick,	Cambridge.

Section II. — 7.

Philology and Archæology.

Ingram Bywater,	Oxford.
W. Dörpfeld,	Athens.
Sir John Evans,	Hemel Hempstead.
J. W. A. Kirchhoff,	Berlin.
G. C. C. Maspero,	Paris.
Max Müller,	Oxford.
Karl Weinhold,	Berlin.

Section III. — 6.

Political Economy and History.

Duc de Broglie,	Paris.
James Bryce,	London.
Herman Grimm,	Berlin.
Theodor Mommsen,	Berlin.
William Stubbs,	Oxford.
Sir G. O. Trevelyan, Bart.,	London.

Section IV. — 5.

Literature and the Fine Arts.

Georg Brandes,	Copenhagen.
F. Brunetière,	Paris.
Jean Léon Gérôme,	Paris.
Rudyard Kipling,	Rottingdean.
Leslie Stephen,	London.

STATUTES AND STANDING VOTES.

STATUTES.

Adopted May 30, 1854: *amended September* 8, 1857, *November* 12, 1862, *May* 24, 1864, *November* 9, 1870, *May* 27, 1873, *January* 26, 1876, *June* 16, 1886, *October* 8, 1890, *January* 11 *and May* 10, 1893, *April* 11, *May* 9, *and October* 10, 1894, *and March* 13, *April* 10, *and May* 8, 1895.

CHAPTER I.

OF FELLOWS AND FOREIGN HONORARY MEMBERS.

1. The Academy consists of *Fellows* and *Foreign Honorary Members.* They are arranged in three Classes, according to the Arts and Sciences in which they are severally proficient, viz.: Class I. The Mathematical and Physical Sciences; — Class II. The Natural and Physiological Sciences; — Class III. The Moral and Political Sciences. Each Class is divided into four Sections, viz.: Class I., Section 1. Mathematics and Astronomy; — Section 2. Physics; — Section 3. Chemistry; — Section 4. Technology and Engineering. Class II., Section 1. Geology, Mineralogy, and Physics of the Globe; — Section 2. Botany; — Section 3. Zoölogy and Physiology; — Section 4. Medicine and Surgery. Class III., Section 1. Philosophy and Jurisprudence; — Section 2. Philology and Archæology; — Section 3. Political Economy and History; — Section 4. Literature and the Fine Arts.

2. Fellows, resident in the State of Massachusetts, only, may vote at the meetings of the Academy.* Each Resident Fellow shall pay an admission fee of ten dollars and such annual assessment, not exceeding ten dollars, as shall be voted by the Academy at each Annual Meeting.

* The number of Resident Fellows is limited by the Charter to 200.

3. Fellows residing out of the State of Massachusetts shall be known and distinguished as Associate Fellows. They shall not be liable to the payment of any fees or annual dues, but on removing within the State shall be admitted to the privileges,* and be subject to the obligations, of Resident Fellows. The number of Associate Fellows shall not exceed *one hundred*, of whom there shall not be more than *forty* in either of the three Classes of the Academy.

4. The number of Foreign Honorary Members shall not exceed *seventy-five;* and they shall be chosen from among persons most eminent in foreign countries for their discoveries and attainments in either of the three departments of knowledge above enumerated. And there shall not be more than *thirty* Foreign Members in either of these departments.

CHAPTER II.

Of Officers.

1. There shall be a President, three Vice-Presidents, one for each Class, a Corresponding Secretary, a Recording Secretary, a Treasurer, and a Librarian, which officers shall be annually elected, by ballot, at the Annual Meeting, on the second Wednesday in May.

2. At the same time, and in the same manner, nine Councillors shall be elected, three from each Class of the Academy, but the same Fellows shall not be eligible on more than three successive years. These nine Councillors, with the President, the three Vice-Presidents, the two Secretaries, the Treasurer, and the Librarian, shall constitute the Council. It shall be the duty of this Council to exercise a discreet supervision over all nominations and elections. With the consent of the Fellow interested, they shall have power to make transfers between the several Sections of the same Class, reporting their action to the Academy.

3. If any office shall become vacant during the year, the vacancy shall be filled by a new election, and at the next stated meeting, or at a meeting called for this purpose.

---

* Associate Fellows may attend, but cannot vote, at meetings of the Academy. See Chapter I. 2.

CHAPTER III.

Of Nominations of Officers.

1. At the stated meeting in March, the President shall appoint from the next retiring Councillors a Nominating Committee of three Fellows, one for each class.

2. It shall be the duty of this Nominating Committee to prepare a list of candidates for the offices of President, Vice-Presidents, Corresponding Secretary, Recording Secretary, Treasurer, Librarian, Councillors, and the Standing Committees which are chosen by ballot; and to cause this list to be sent by mail to all the Resident Fellows of the Academy not later than four weeks before the Annual Meeting.

3. Independent nominations for any office, signed by at least five Resident Fellows and received by the Recording Secretary not less than ten days before the Annual Meeting, shall be inserted in the call for the Annual Meeting, which shall then be issued not later than one week before that meeting.

4. The Recording Secretary shall prepare for use, in voting at the Annual Meeting, a ballot containing the names of all persons nominated for office under the conditions given above.

5. When an office is to be filled at any other time than at the Annual Meeting, the President shall appoint a Nominating Committee, in accordance with the provisions of Section 1, which shall announce its nomination in the manner prescribed in Section 2 at least two weeks before the time of election. Independent nominations, signed by at least five Resident Fellows and received by the Recording Secretary not later than one week before the meeting for election, shall be inserted in the call for that meeting.

CHAPTER IV.

Of the President.

1. It shall be the duty of the President, and, in his absence, of the senior Vice-President present, or next officer in order as above enumerated, to preside at the meetings of the Academy; to summon extraordinary meetings, upon any urgent occasion; and to execute or see to the execution of the Statutes of the

Academy. Length of continuous membership in the Academy shall determine the seniority of the Vice-Presidents.

2. The President, or, in his absence, the next officer as above enumerated, is empowered to draw upon the Treasurer for such sums of money as the Academy shall direct. Bills presented on account of the Library, or the Publications of the Academy, must be previously approved by the respective committees on these departments.

3. The President, or, in his absence, the next officer as above enumerated, shall nominate members to serve on the different committees of the Academy which are not chosen by ballot.

4. Any deed or writing to which the common seal is to be affixed shall be signed and sealed by the President, when thereto authorized by the Academy.

CHAPTER V.

Of Standing Committees.

1. At the Annual Meeting there shall be chosen the following Standing Committees, to serve for the year ensuing, viz.: —

2. The Committee of Finance, to consist of the President, Treasurer, and one Fellow chosen by ballot, who shall have charge of the investment and management of the funds and trusts of the Academy. The general appropriations for the expenditures of the Academy shall be moved by this Committee at the Annual Meeting, and all special appropriations from the general and publication funds shall be referred to or proposed by this Committee.

3. The Rumford Committee, of seven Fellows, to be chosen by ballot, who shall consider and report on all applications and claims for the Rumford Premium, also on all appropriations from the income of the Rumford Fund, and generally see to the due and proper execution of this trust.

4. The C. M. Warren Committee, of seven Fellows, to be chosen by ballot, who shall consider and report on all applications for appropriations from the income of the C. M. Warren Fund, and generally see to the due and proper execution of this trust.

5. The Committee of Publication, of three Fellows, to whom all memoirs submitted to the Academy shall be referred, and to

whom the printing of memoirs accepted for publication shall be intrusted.

6. The Committee on the Library, of three Fellows, who shall examine the Library, and make an annual report on its condition and management.

7. An Auditing Committee, of two Fellows, for auditing the accounts of the Treasurer.

CHAPTER VI.

Of the Secretaries.

1. The Corresponding Secretary shall conduct the correspondence of the Academy, recording or making an entry of all letters written in its name, and preserving on file all letters which are received; and at each meeting he shall present the letters which have been addressed to the Academy since the last meeting. With the advice and consent of the President, he may effect exchanges with other scientific associations, and also distribute copies of the publications of the Academy among the Associate Fellows and Foreign Honorary Members, as shall be deemed expedient; making a report of his proceedings at the Annual Meeting. Under the direction of the Council for Nomination, he shall keep a list of the Fellows, Associate Fellows, and Foreign Honorary Members, arranged in their Classes and in Sections in respect to the special sciences in which they are severally proficient; and he shall act as secretary to the Council.

2. The Recording Secretary shall have charge of the Charter and Statute-book, journals, and all literary papers belonging to the Academy. He shall record the proceedings of the Academy at its meetings; and after each meeting is duly opened, he shall read the record of the preceding meeting. He shall notify the meetings of the Academy, and apprise committees of their appointment. He shall post up in the Hall a list of the persons nominated for election into the Academy; and when any individual is chosen, he shall insert in the record the names of the Fellows by whom he was nominated.

3. The two Secretaries, with the Chairman of the Committee of Publication, shall have authority to publish such of the proceedings of the Academy as as may seem to them calculated to promote the interests of science.

CHAPTER VII.

Of the Treasurer.

1. The Treasurer shall give such security for the trust reposed in him as the Academy shall require.

2. He shall receive officially all moneys due or payable, and all bequests or donations made to the Academy, and by order of the President or presiding officer shall pay such sums as the Academy may direct. He shall keep an account of all receipts and expenditures; shall submit his accounts to the Auditing Committee; and shall report the same at the expiration of his term of office.

3. The Treasurer shall keep a separate account of the income and appropriation of the Rumford Fund, and report the same annually.

4. All moneys which there shall not be present occasion to expend shall be invested by the Treasurer, under the direction of the Finance Committee, on such securities as the Academy shall direct.

CHAPTER VIII.

Of the Librarian and Library.

1. It shall be the duty of the Librarian to take charge of the books, to keep a correct catalogue of same, and to provide for the delivery of books from the Library. He shall also have the custody of the publications of the Academy.

2. The Librarian, in conjunction with the Committee on the Library, shall have authority to expend, as they may deem expedient, such sums as may be appropriated, either from the Rumford or the General Fund of the Academy, for the purchase of books, and for defraying other necessary expenses connected with the Library. They shall have authority to propose rules and regulations concerning the circulation, return, and safe-keeping of books; and to appoint such agents for these purposes as they may think necessary.

3. To all books in the Library procured from the income of the Rumford Fund, the Librarian shall cause a stamp or label to be affixed, expressing the fact that they were so procured.

4. Every person who takes a book from the Library shall give a receipt for the same to the Librarian or his assistant.

5. Every book shall be returned in good order, regard being had to the necessary wear of the book with good usage. And if any book shall be lost or injured, the person to whom it stands charged shall replace it by a new volume or set, if it belongs to a set, or pay the current price of the volume or set to the Librarian; and thereupon the remainder of the set, if the volume belonged to a set, shall be delivered to the person so paying for the same.

6. All books shall be returned to the Library for examination at least one week before the Annual Meeting.

CHAPTER IX.

Of Meetings.

1. There shall be annually four stated meetings of the Academy; namely, on the second Wednesday in May (the Annual Meeting), on the second Wednesday in October, on the second Wednesday in January, and on the second Wednesday in March. At these meetings only, or at meetings adjourned from these and regularly notified, shall appropriations of money be made, or alterations of the statutes or standing votes of the Academy be effected.

2. Fifteen Fellows shall constitute a quorum for the transaction of business at a stated meeting. Seven Fellows shall be sufficient to constitute a meeting for scientific communications and discussions.

3. The Recording Secretary shall notify the meetings of the Academy to each Fellow residing in Boston and the vicinity; and he may cause the meetings to be advertised, whenever he deems such further notice to be needful.

CHAPTER X.

Of the Election of Fellows and Honorary Members.

1. Elections shall be made by ballot, and only at stated meetings.

2. Candidates for election as Resident Fellows must be proposed by two or more Resident Fellows, in a recommendation signed by them, specifying the Section to which the nomination is made, which recommendation shall be transmitted to the Corresponding Secretary, and by him referred to the Council for Nomination. No person recommended shall be reported by the Council as a candidate for election, unless he shall have received a written approval, signed at a meeting of the Council by at least seven of its members. All nominations thus approved shall be read to the Academy at a stated meeting, and shall then stand on the nomination list during the interval between two stated meetings, and until the balloting. No person shall be elected a Resident Fellow, unless he shall have been resident in this Commonwealth one year next preceding his election. If any person elected a Resident Fellow shall neglect for one year to pay his admission fee, his election shall be void; and if any Resident Fellow shall neglect to pay his annual assessments for two years, provided that his attention shall have been called to this article, he shall be deemed to have abandoned his Fellowship; but it shall be in the power of the Treasurer, with the consent of the Council, to dispense (*sub silentio*) with the payment both of the admission fee and of the assessments, whenever in any special instance he shall think it advisable so to do.

3. The nomination of Associate Fellows shall take place in the manner prescribed in reference to Resident Fellows; and after such nomination shall have been publicly read at a stated meeting previous to that when the balloting takes place, it shall be referred to the Council for Nomination; and a written approval, authorized and signed at a meeting of said Council by at least seven of its members, shall be requisite to entitle the candidate to be balloted for. The Council may in like manner originate nominations of Associate Fellows, which must be read at a stated meeting previous to the election, and be exposed on the nomination list during the interval.

4. Foreign Honorary Members shall be chosen only after a nomination made at a meeting of the Council, signed at the time by at least seven of its members, and read at a stated meeting previous to that on which the balloting takes place.

5. Three fourths of the ballots cast must be affirmative, and the number of affirmative ballots must amount to eleven to effect an election of Fellows or Foreign Honorary Members.

6. Each Section of the Academy is empowered to present lists of persons deemed best qualified to fill vacancies occurring in the number of Foreign Honorary Members or Associate Fellows allotted to it; and such lists, after being read at a stated meeting, shall be referred to the Council for Nomination.

7. If, in the opinion of a majority of the entire Council, any Fellow — Resident or Associate — shall have rendered himself unworthy of a place in the Academy, the Council shall recommend to the Academy the termination of his Fellowship; and provided that a majority of two thirds of the Fellows at a stated meeting, consisting of not less than fifty Fellows, shall adopt this recommendation, his name shall be stricken off the roll of Fellows.

CHAPTER XI.

OF AMENDMENTS OF THE STATUTES.

1. All proposed alterations of the Statutes, or additions to them, shall be referred to a committee, and, on their report at a subsequent meeting, shall require for enactment a majority of two thirds of the members present, and at least eighteen affirmative votes.

2. Standing Votes may be passed, amended, or rescinded, at any stated meeting, by a majority of two thirds of the members present. They may be suspended by a unanimous vote.

CHAPTER XII.

OF LITERARY PERFORMANCES.

1. The Academy will not express its judgment on literary or scientific memoirs or performances submitted to it, or included in its publications.

STANDING VOTES.

1. Communications of which notice had been given to the Secretary shall take precedence of those not so notified.

2. Resident Fellows who have paid all fees and dues chargeable to them are entitled to receive one copy of each volume or article printed by the Academy, on application to the Librarian personally or by written order, within two years from the date of publication. And the current issues of the Proceedings shall be supplied, when ready for publication, free of charge, to all the Fellows and members of the Academy who desire to receive them.

3. The Committee of Publication shall fix from time to time the price at which the publications of the Academy may be sold. But members may be supplied at half this price with volumes which they are not entitled to receive free, and which are needed to complete their sets.

4. Two hundred extra copies of each paper accepted for publication in the Memoirs or Proceedings of the Academy shall be placed at the disposal of the author, free of charge.

5. Resident Fellows may borrow and have out from the Library six volumes at any one time, and may retain the same for three months, and no longer.

6. Upon special application, and for adequate reasons assigned, the Librarian may permit a larger number of volumes, not exceeding twelve, to be drawn from the Library for a limited period.

7. Works published in numbers, when unbound, shall not be taken from the Hall of the Academy, except by special leave of the Librarian.

8. Books, publications, or apparatus shall be procured from the income of the Rumford Fund only on the certificate of the Rumford Committee that they, in their opinion, will best facilitate and encourage the making of discoveries and improvements which may merit the Rumford Premium.

9. The Annual Meeting and the other stated meetings shall be holden at eight o'clock, P. M.

10. A meeting for receiving and discussing scientific communications may be held on the second Wednesday of each month not appointed for stated meetings, excepting July, August, and September.

RUMFORD PREMIUM.

In conformity with the terms of the gift of Be
Rumford, granting a certain fund to the America
Arts and Sciences, and with a decree of the Sup
Court for carrying into effect the general charita
purpose of Count Rumford, as expressed in his let
Academy is empowered to make from the income o
it now exists, at any Annual Meeting, an award
silver medal, being together of the intrinsic v
hundred dollars, as a premium to the author of
discovery or useful improvement in light or in hea
have been made and published by printing, or in
known to the public, in any part of the continent
any of the American islands; preference being al
such discoveries as shall, in the opinion of the
most to promote the good of mankind; and t
medals, as a further premium for such discovery
ment, if the Academy see fit so to do, a sum
exceeding three hundred dollars.

INDEX.

PUBLICATIONS

OF THE

AMERICAN ACADEMY OF ARTS AND SCIENCES.

MEMOIRS. Old Series, Vols. I.–IV.; New Series, Vols. I.–XII. 16 volumes, $10 each. Half volumes, $5 each. 25% discount to booksellers; 50% to members.

Vol. X.	Part II. *bis*	. . . . . .	$1.75
" XI.	" I.	. . . .	2.00
" XI.	" II. No. I.	. . . . . .	3.00
" XI.	" III. " II.–III.	. . .	1.00
" XI.	" IV. " IV.	. . . . . .	1.00
" XI.	" IV. " V.	. . . . . .	.75
" XI.	" V. " VI.	. . . . . .	.25
" XI.	" VI. " VII.	. . . . .	2.00
" XII.	No. I.	. . . .	1.50
" XII.	" II.	. . . .	2.00
" XII.	" III.	. . . .	6.00
" XII.	" IV.	. . . .	1.25

PROCEEDINGS. Vols. I.–XXXIV., $5 each. 25% discount to booksellers; 50% discount to members.

Complete sets of the Memoirs. 15 vols., for $112.50, to members, $60; of the Proceedings, 34 vols. for $129, to members, $68.